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19

VOLUME 5
FINAL REMEDIAL INVESTIGATION REPORT
APPENDIX E1 - BASELINE RISK ASSESSMENT
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HIMCO DUMP
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
ELKHART, INDIANA

AUGUST 1992

Prepared for:

U.S. Environmental Protection Agency
Emergency and Remedial Response Branch
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APPENDIX E1

BASELINE RISK ASSESSMENT

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TR-1107-31B

BASELINE RISK ASSESSMENT - HUMAN HEALTH EVALUATION

RI/FS Support for the Himco Dump Site

Prepared Under

Program No. 1522

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for

ICAIR Work Assignment No. 101522

Donohue Work Assignment No. 17-5L4J

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LIST OF ACRONYMS

CLP	Contract Laboratory Program
CRDL	Contract Required Detection Limit
CTV	Critical Toxicity Value
ECAO	Environmental Criteria and Assessment Office
ED	Exposure Duration
EF	Exposure Frequency
FIT	Field Investigation Team
HI	Hazard Index
HIF	Human Intake Factor
ISBH	Indiana State Board of Health
LOAEL	Lowest-Observed-Adverse-Effect Level
MSL	Mean Sea Level
NOAEL	No-Observed-Adverse-Effect Level
NPL	National Priorities List
PAH	Polycyclic Aromatic Hydrocarbon
PC	Permeability Constant
PCB	Polychlorinated Biphenyl
RAGS	Risk Assessment Guidance for Superfund
RAS	Routine Analytical Service
RDA	Recommended Dietary Allowance
RDI	Recommended Daily Intake
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
SAS	Special Analytical Services
SF	Slope Factor
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TFV	Threshold Friction Velocity
TIC	Tentatively Identified Compound
UBK	Uptake/Biokinetic
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound

1.0 INTRODUCTION

1.1 Overview

This baseline human health risk assessment (risk assessment) was conducted to evaluate potential adverse risks to human populations resulting from exposures to hazardous substances at the Himco Dump site in Elkhart, Indiana. By definition, a baseline risk assessment is limited to conditions under the no-action alternative, that is, in absence of any remedial actions to control or mitigate releases, including institutional controls.

The methods and procedures used in this risk assessment are consistent with U.S. Environmental Protection Agency (USEPA) guidance, including the Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (RAGS) (USEPA 1989a), the Exposure Factors Handbook (USEPA 1989b), the Superfund Exposure Assessment Manual (USEPA 1988a) and Standard Default Exposure Factors in OSWER Directive 9285.6-03 (USEPA 1991c). Additional USEPA guidance and other technical information have also been used and are referenced where appropriate.

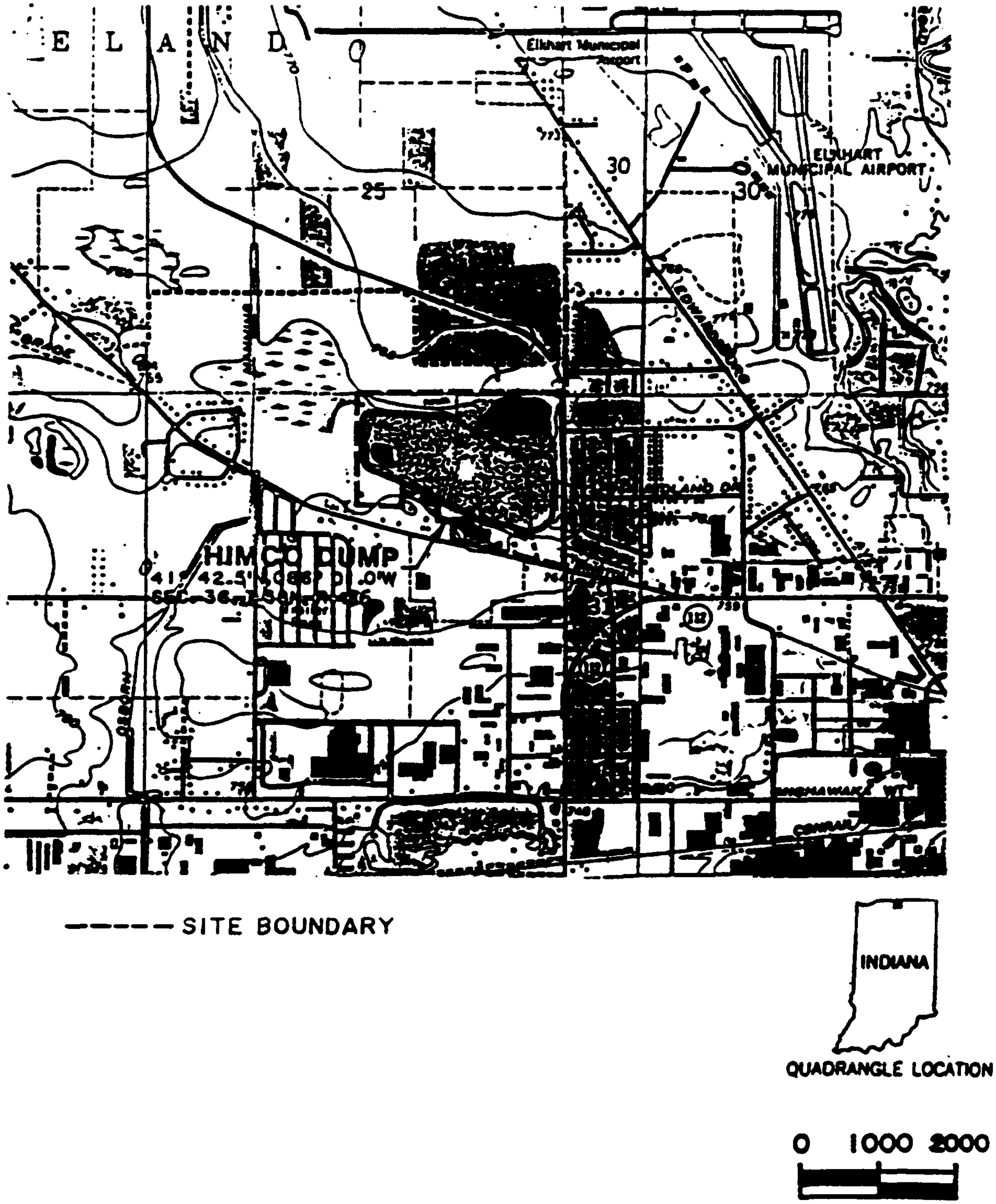
1.2 Site Background

The Himco Dump site (site) is a closed landfill located at County Road 10 and Nappanee Street Extension in the city of Elkhart, Indiana. The site is approximately 50 acres and is bordered by roads and residences on the south and east sides and tree lines and surface water bodies on the north and west sides. Figure 1-1 illustrates the location and boundaries of the site. Figure 1-2 indicates the major features of the site as it currently exists.

The Himco Dump site was privately operated by Himco Waste Away Services, Inc. and used as a landfill. The landfill had no liner, leachate or gas recovery system. Wastes were placed directly onto the ground surface or into five trenches each 10 to 15 feet deep. The trenches were also used for burning of paper wastes. Wastes were covered daily with sandy soil from the quarry pit, from on-site excavated ponds or from the periphery of the site. Wastes consisted primarily of calcium sulfate (from a pharmaceutical source) with lesser amounts of other pharmaceutical, industrial, construction and household wastes. The landfill was operated until 1975 when it was closed and a cover of calcium sulfate and sand was placed over the landfill.

In 1974, residents near the site complained to the State Board of Health about color, taste and odor problems in their shallow drinking water wells. In response, their shallow (22 feet) wells were replaced by deeper (152 to 172 feet) wells. In 1981, the U.S. Geological Survey (USGS) in cooperation with the Indiana Department of Natural Resources and the Elkhart Water Works reported on a three-year groundwater resources study. The USGS characterized the extent of a potential leachate plume (based on concentrations of bromide) from the site.

In 1984, a USEPA field investigation team (FIT) conducted a site inspection of the dump and determined that groundwater was impacted by metals and volatile and semivolatile chemicals. At the time of the site inspections, leachate seeps were observed but not characterized.



SOURCE: USGS 7.5 MIN. QUAD ELKHART, INDIANA, 1961
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FIGURE 1-1 SITE LOCATION MAP HIMCO DUMP SITE ELKHART, INDIANA

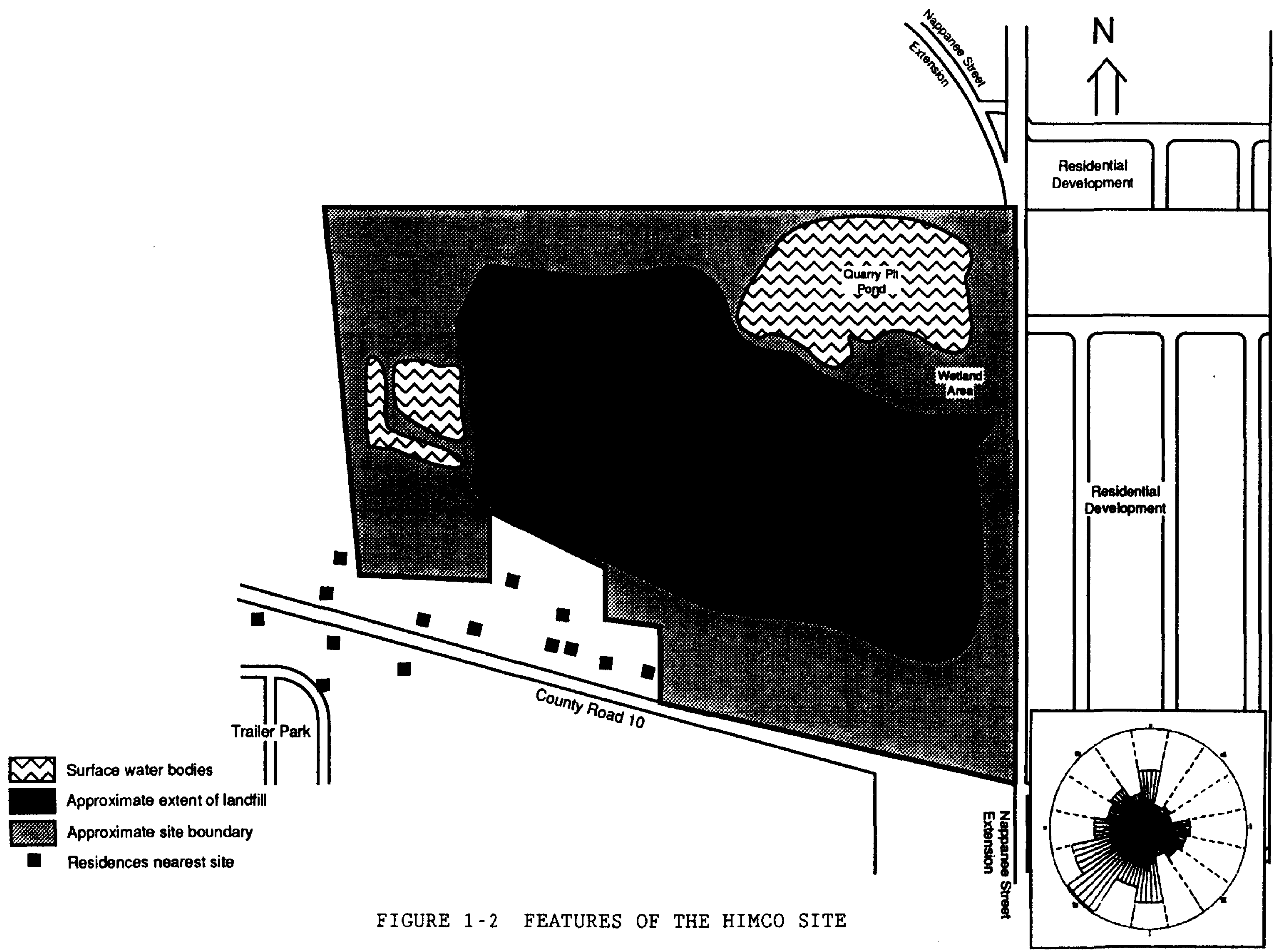


FIGURE 1-2 FEATURES OF THE HIMCO SITE

In 1988, the Himco Dump site was proposed for the National Priorities List (NPL) and in February 1990 was designated a final NPL site.

In September 1989, SEC Donohue initiated a Remedial Investigation/Feasibility Study. During the investigation two emergency response actions were undertaken. In April 1990, USEPA's Emergency and Response Branch sampled residential wells downgradient of the site and as a result those residents were provided municipal water service by November 1990. In May 1992, a site assessment focused on the south/southwest section of the landfilled area where quantities of volatile compounds were discovered in leaking drums. Seventy-one, 55-gallon drums were subsequently removed.

1.3 Scope of the Risk Assessment

The scope of this risk assessment is limited to potential risks to human populations exposed to environmental contamination at the Himco Dump site. The data utilized in this evaluation are limited to data collected during Phase I and Phase II of the Remedial Investigation (RI). This human health evaluation together with the environmental evaluation (ecological assessment) comprise the baseline risk assessment (or endangerment assessment) for the site. The environmental evaluation is documented in a separate report (Life Systems 1992).

1.4 Organization of the Risk Assessment Report

The format of this report follows USEPA's (1989a) recommended outline and is organized into eight sections, including this introductory section.

Section 2.0, Identification of Chemicals of Potential Concern, summarizes the environmental data collection and details the selection of chemicals of potential concern. Section 3.0 summarizes the exposure assessment including the identification of potentially exposed populations and evaluation of current and future exposure pathways. The exposure assessment also provides estimates of environmental concentrations of contaminants at exposure points and contaminant intakes for specific pathways. The toxicity assessment, Section 4.0, summarizes the carcinogenic and noncarcinogenic health effects related to the chemicals of potential concern. Section 5.0, Risk Characterization, combines the results of the exposure and toxicity assessments and characterizes the potential for adverse health effects. Section 6.0 is an assessment of the uncertainties related to this risk assessment. Section 7.0 is a summary of the risk assessment and Section 8.0 is the reference list.

This report also contains six appendices. Appendix 1 provides additional detail on the sampling data. Appendices 2 and 3 describe the methodology and calculations for the evaluation of the air pathway. Appendix 4 documents the calculation of exposure point concentrations. Appendix 5 contains detailed calculations of exposure and risk for the exposure scenarios quantified in this risk assessment. Appendix 6 contains expanded toxicity summaries for chemicals contributing to risk.

2.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

Chemicals of potential concern are chemicals present at the site that could pose a risk of adverse health effects to exposed humans. The selection of these chemicals is based mainly on the results of chemical analyses of environmental media from the site. Chemicals of potential concern normally include all toxic chemicals that have been released by waste disposal at the site, but may also include naturally-occurring toxic chemicals and toxic chemicals that have reached the site by environmental transport from other sources. If the risk assessment indicates that one or more of these chemicals poses sufficient risk to be of concern, then more detailed evaluations of the relative magnitude of the risks from each source (on-site waste, naturally-occurring chemicals, chemicals transported from other sources) may be needed to provide the basis for evaluation of remedial alternatives and other risk management decisions.

2.1 Overview of Sampling

2.1.1 Historical Data

The following information, obtained from Donohue Work Plans (Donohue & Associates 1990a, 1991a), summarizes site sampling activities prior to the RI.

The Indiana State Board of Health (ISBH) analyzed residential wells immediately south of the site in 1974 in response to residents' complaints about color, taste and odor problems. The analyses indicated high levels of manganese in the shallow wells (approximately 22 feet deep), and this resulted in the drilling of deeper wells (152 to 172 feet deep).

In 1981, the USGS conducted a groundwater resources study which determined the extent of a potential leachate plume (bromide) from the site. The plume (evaluated 1979 through 1987) appeared to be extending and moving to the south-southeast toward the St. Joseph River.

In 1984, the FIT determined that groundwater downgradient of the site was impacted by metals, volatiles and semivolatiles. Detected metals included aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium and zinc. Detected volatiles and semivolatiles included acetone, benzene, phenol, freons, 4-methylphenol, trans-1,2-dichloroethane, 2-butanone, chloroethane and pyrene.

2.1.2 Remedial Investigation Data

During the RI, sampling and analysis of surface, subsurface and suspected wetland soils, groundwater, surface water and sediments were undertaken to determine the magnitude and extent of contamination and to supply data adequate for a risk assessment. The remedial investigation also included excavation of test pits, geotechnical analysis and waste mass gas sampling (landfill and residential). The monitoring associated with the Himco RI was accomplished in two phases: Phase I (October 1990 through February 1991) and Phase II (September and November 1991). Table 2-1 summarizes the number of

TABLE 2-1 SUMMARY OF RI SAMPLES - PHASE I AND II

Medium	Number of Phase I Samples	Number of Phase II Samples	Total Number of Samples
Landfill Cap/Miscellaneous Soil	12	11	23
Wetland Soil	16	3	19
Soil Sample from Soil Boring - Chemical	30	3	33
Surface Water	12	9	21
Sediment	12	9	21
Leachate	0	4	4
Monitoring Wells	36	19	55
Residential Wells	8	0	8

samples taken during each phase on a medium by medium basis. Figure 2-1 indicates site locations across the site where samples were taken. These sampling efforts are described in detail in the RI Report (SEC Donohue Inc. 1992) and are briefly summarized in the following sections.

Soil Sampling

A series of surficial soil samples (GS01...GS12) were collected in November 1990 from depths as shallow as 3 to 9 inches and as deep as 8 to 16 inches from the existing landfill cover. Depth varied dependent upon the thickness of the overlying topsoil and sand cover. This cover material was removed prior to sampling at each location. Soil was also sampled when six shallow observation wells were installed on or adjacent to the site in November 1990. Samples (GT01...GT06) were taken at two-foot intervals from the surface to a maximum depth of 16 feet and correspond to well numbers WT101 through WT106. All samples were analyzed for the inorganic analytes on the Target Analyte List (TAL) and the compounds on the Target Compound List (TCL) including volatiles and semivolatiles, polychlorinated biphenyls (PCBs) and pesticides by Contract Laboratory Program (CLP) Routine Analytical Services (RAS). Selected samples were analyzed for grain size and other geotechnical analyses.

During Phase II additional surficial soil samples (HS01...HS09) were taken along the dirt bike trail, near the L-shaped pond and in the area south of the landfill cap. Two soil samples were also taken in the area southeast of the landfill (Trench 3) and were analyzed for all TCL/TAL analytes from Trench 3 (at 2 feet and 6 feet).

Nineteen soil samples (WS01...WS19) were taken in both phases from the areas suspected (at the time of sampling) to be wetlands. Six samples were from the area surrounding the two small surface water bodies, four from the area north of County Road 10 and nine from the area adjacent to the quarry pit pond. Samples were composited typically from 0 to 18 inches at each location. Samples were analyzed by RAS for TCL and TAL chemicals.

Groundwater Sampling

A total of 34 groundwater wells were sampled during the RI. The locations of these wells are indicated on Figure 2-2. The wells sampled included 11 wells installed during the RI, 23 USGS wells installed in 1977 and 1979. During both phases wells were analyzed for the analytes on the TCL/TAL, bromide and additional water quality parameters.

Groundwater samples (RW01...RW08) were collected in October 1990 from five residential wells immediately south of the site and one residential well immediately south of County Road 10 (Figure 2-1). At the time of sampling, two of these residences still had access to older shallow wells in addition to their deep wells, and these two shallow wells were also sampled. The deep water well samples were taken at the tap at the kitchen sink, or if available,

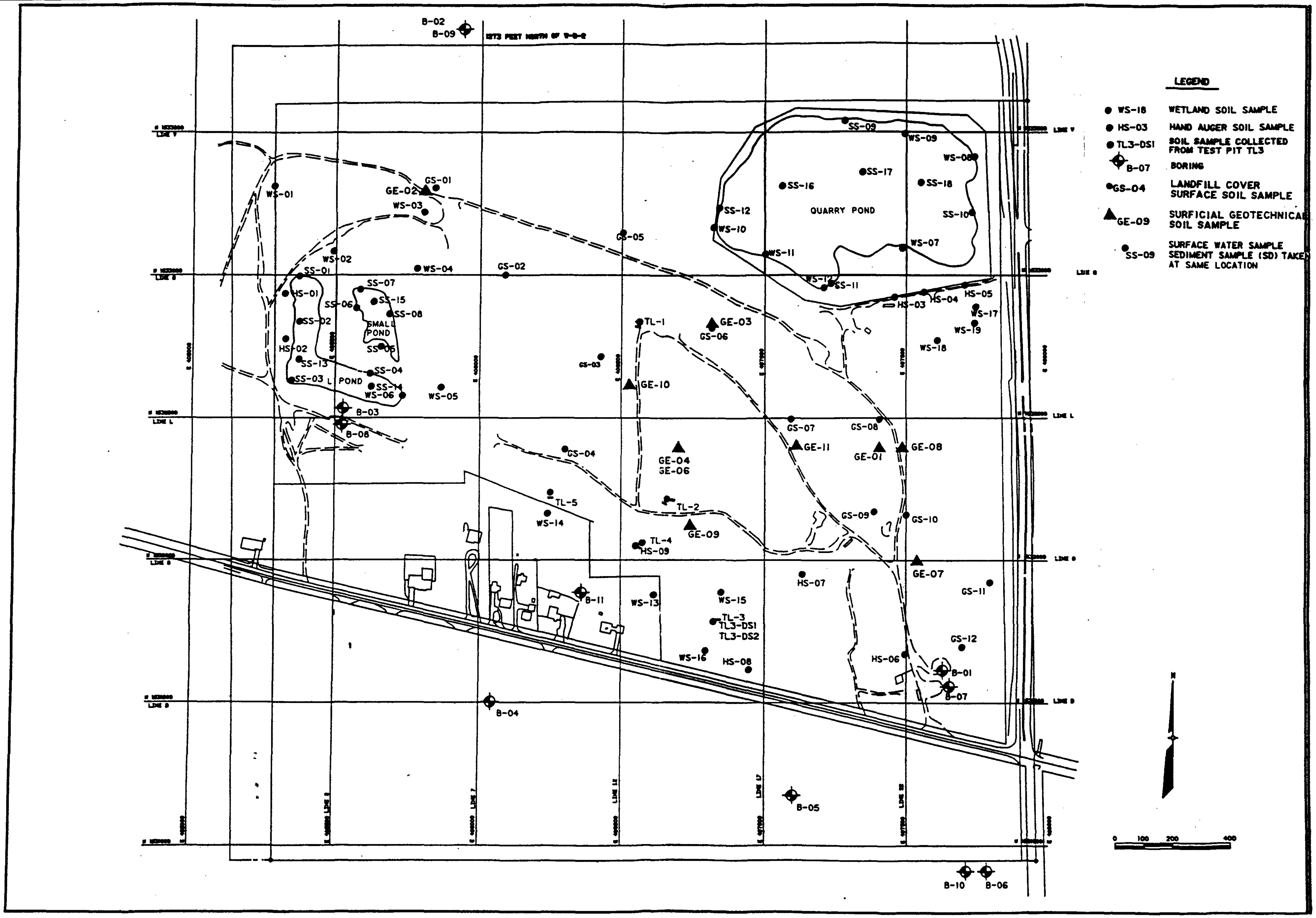


FIGURE 2-1 REMEDIAL INVESTIGATION SAMPLING LOCATIONS

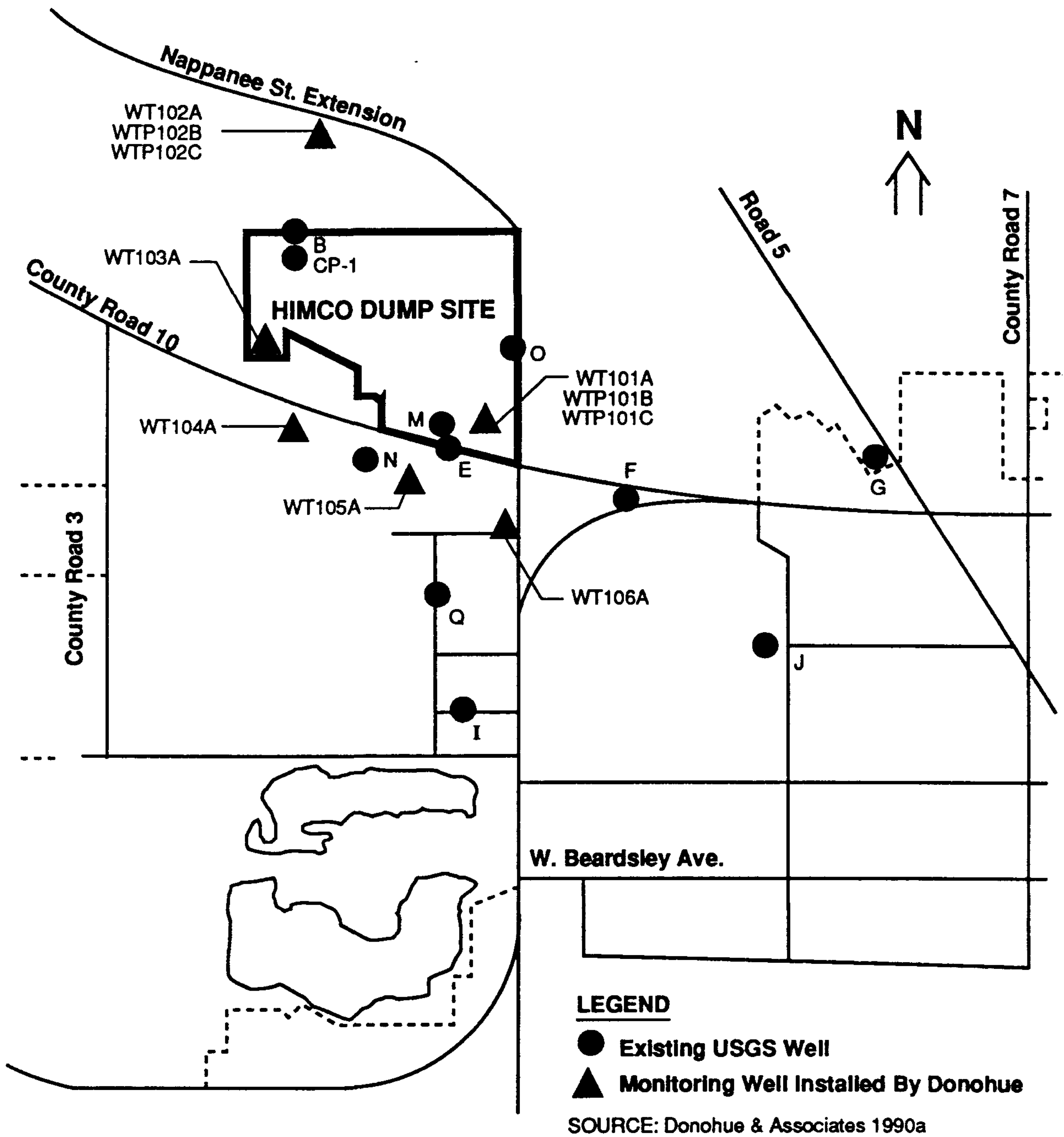


FIGURE 2-2 GROUNDWATER WELL LOCATIONS

available, at a tap in the basement ahead of the water softener. Shallow wells were sampled by bailing. These samples were analyzed by Special Analytical Services (SAS) for all TCL and TAL chemicals.

Trenching/Leachate Collection

Thirty-three test pits (approximately twenty-five feet long) were excavated to a maximum depth of approximately 15 feet (unless the water table was reached first) either on the landfill cap (Phase I) or in the south of the landfill cover (Phase II). The excavation uncovered several crushed drums and drum lids, scrap metal grips, sheet metal, refrigerator condensers and other miscellaneous metallic items. After information on the wastes observed in the pits was collected, the pits were backfilled. During Phase II leachate samples were collected from trenches 1 through 5. These samples were analyzed for TAL/TCL analytes and water quality parameters.

Surface Water and Sediment Sampling

A total of 18 surface water and sediment samples were collected from the three ponds on site. During Phase I, twelve locations were sampled. The locations were selected so that each north, south, east and west shoreline was sampled. The surface water samples were collected prior to the sediment samples and on different days. Sediment samples were collected at the same locations as the surface water samples, approximately 2 to 3 feet offshore and at water depths from 0 to 2 feet. All samples were analyzed for all TAL and TCL chemicals by RAS. Water quality parameters were also determined for all surface water samples. During Phase II, nine surface water and sediment were collected, six from the three on-site ponds and three samples from a background pond located approximately two miles northeast of the site.

Waste Mass Gas Survey

A waste mass gas survey was completed to characterize the extent and degree of contamination on site. Twelve soil cap locations on site were sampled at 2-to 3-foot depths. The survey detected compounds indicative of disposal of aerosol cans (1,1,2-trichloroethane and 1,2,2-trifluoroethane), solvents (methylene chloride, acetone, benzene, toluene and 1,1,1-trichloroethane) and landfill gas (carbon disulfide).

Residential Gas Sampling

The basements of four residences on County Road 10 were screened for the presence of landfill gases (methane and hydrogen sulfide). No landfill gases were detected.

2.2 Data Quality

All analyses of data collected during the RI sampling were reviewed and validated by USEPA, according to procedures described in USEPA (1988b,c). During this effort USEPA reviewed data qualifiers as reported by the laboratory, reviewed quality control information and concluded whether the data were usable. As a result, the following decisions were made regarding the use of the data for risk assessment purposes:

- Chemicals which were analyzed for but were not detected were reported with a "U." These sample results, including those qualified with a "UJ," were used in the risk assessment as nondetects.

- Any concentration values for organics or inorganics deviating in minor ways from CLP requirements for holding times, analytical spikes, duplicates or other quality control parameters were considered estimated values and were reported with a "J." These values were used in the risk assessment as if they were unqualified.

- Any inorganic concentration values reported as less than the contract required detection limit (CRDL) but greater than the instrument detection limit were qualified with a "B." These values were used in the risk assessment as if they were unqualified.

- Any detected value for an organic chemical which was also detected in the associated blank was qualified with a "B." The sample value was compared to the blank value according to the procedures in USEPA (1988c).

- All values qualified with an "R," indicating the sample results were rejected by the validation personnel, were removed from the data set and were not used in this risk assessment.

2.3 Approach for Identifying Chemicals of Potential Concern

Figure 2-3 diagrams the approach used to select contaminants of potential concern at Himco. As shown, any chemical detected at least once in any on-site soil, groundwater, leachate, surface water or sediment sample was considered to be a possible chemical of concern. Samples considered to be representative of background (i.e., soil at boring locations 02, 04, 05 and 06, groundwater at upgradient wells WT102A through WT102C and WTB, sediment/surface water locations 19 through 21) were not used in the selection process. Due to the uncertainty regarding the integrity of the residential wells, those samples were also not included in the data set used for selection of chemicals of potential concern. The RI concluded that these wells were not representative of aquifer quality due to questionable development (SEC Donohue Inc. 1992).

Table 2-2 lists chemicals never detected in any sample collected during the RI. Table 2-3 summarizes all chemicals detected at least once. Some chemicals listed in Table 2-3 were subsequently excluded from quantitative evaluation for reasons discussed below.

Exclusion Based on Beneficiality

Some inorganic chemicals detected at the site occur naturally in the body (calcium, copper, iron, magnesium, manganese, potassium, selenium, sodium and zinc), and moderate intakes are considered beneficial or essential to good

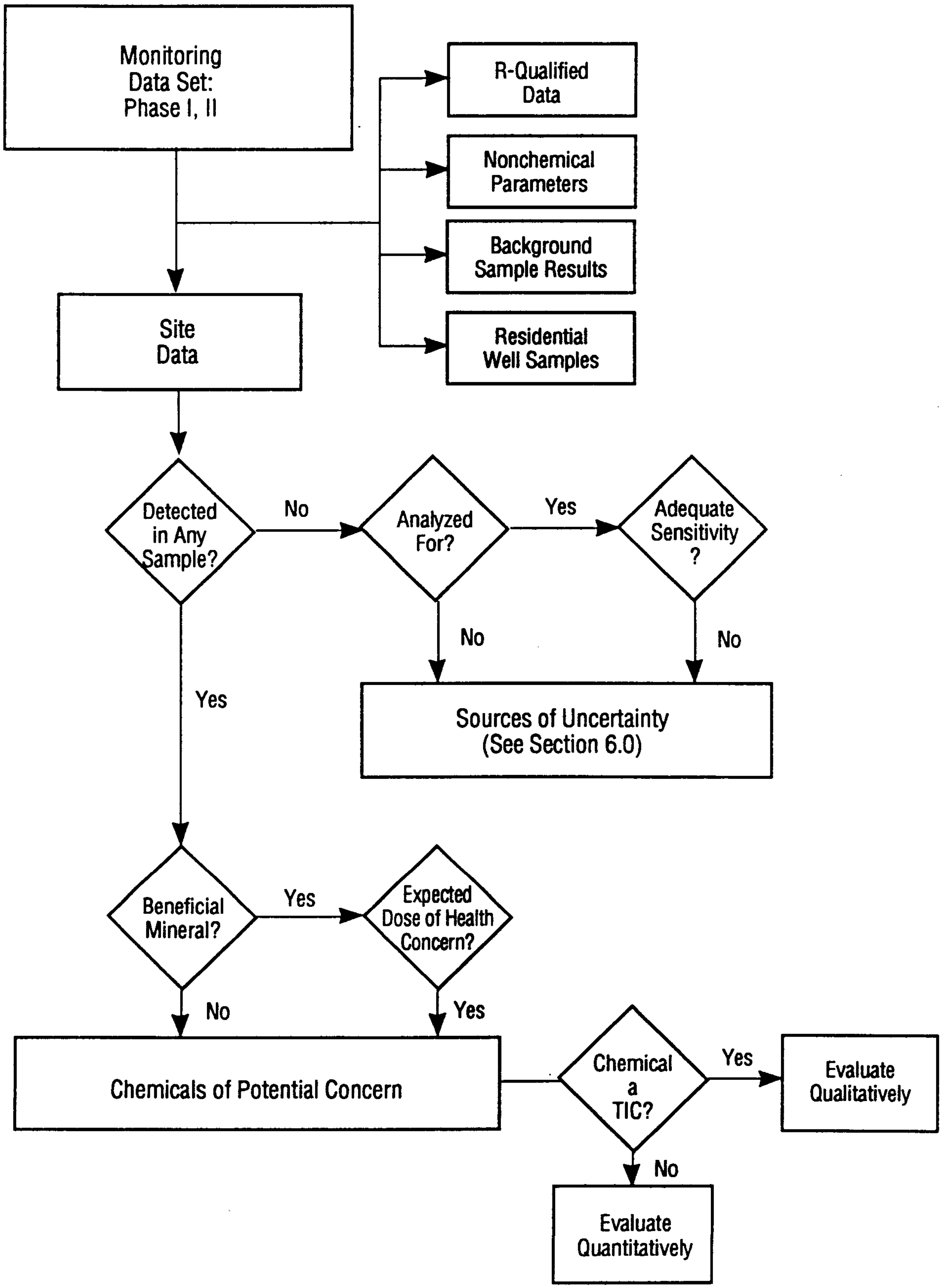


FIGURE 2-3 APPROACH FOR CHOOSING CHEMICALS OF POTENTIAL CONCERN

TABLE 2-2 CHEMICALS NOT DETECTED IN ANY SAMPLE COLLECTED AT THE HIMCO DUMP SITE

VOLATILES

1,1,2-Trichloroethane
1,1,2,2-Tetrachloroethane
1,2-Dichloroethane
1,2-Dichloropropane
1,3-Dichloropropene-cis
1,3-Dichloropropene-trans
Bromoform
Bromomethane
Carbon tetrachloride
Chloromethane
Dibromochloromethane
Vinyl acetate

PESTICIDES/PCB'S

4,4'-DDD
delta-BHC
Endosulfan I
Endosulfan sulfate
Endrin
Endrin ketone
gamma-BHC
Heptachlor epoxide
Methoxychlor
Toxaphene

SEMIVOLATILES

1,2-Dichlorobenzene
1,2,4-Trichlorobenzene
1,3-Dichlorobenzene
2-Chloronaphthalene
2-Chlorophenol
2-Nitroaniline
2-Nitrophenol
2,4-Dichlorophenol
2,4-Dinitrophenol
2,4-Dinitrotoluene
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
2,6-Dinitrotoluene
3-Nitroaniline
3-3'-Dichlorobenzidine
4-Bromophenylphenylether
4-Chloro-3-methylphenol
4-Chloroaniline
4-Chlorophenyl-phenyl ether
4-Nitroaniline
4-Nitrophenol
4,6-Dinitro-2-methylphenol
bis(2-Chloroethoxy)methane
bis(2-Chloroethyl)ether
bis(2-Chloroisopropyl)ether
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Isophorone
Nitrobenzene
N-Nitroso-di-n-dipropylamine
N-Nitrosodiphenylamine
Pentachlorophenol

OTHERS

Acrolein
Acrylonitrile

TABLE 2-3 CHEMICALS DETECTED AT LEAST ONCE - HIMCO DUMP SITE

FRACTION	CHEMICAL	SOIL		GROUNDWATER		SURFACE WATER		SEDIMENT		TRENCH LEACHATE		ALL MEDIA	
		Hits	Total	Hits	Total	Hits	Total	Hits	Total	Hits	Total	Hits	Total
VOLATILES	1,1,1-Trichloroethane	0	56	3	39	0	16	1	18	2	3	6	132
	1,1-Dichloroethane	0	56	3	39	0	18	0	18	3	3	6	134
	1,1-Dichloroethene	1	56	0	39	0	18	0	18	0	3	1	134
	1,2-Dichloroethene(total)	0	56	4	39	0	18	0	18	2	3	6	134
	2-Butanone	7	46	0	39	0	11	3	18	3	4	13	118
	2-Hexanone	0	56	2	39	0	18	0	18	2	5	4	136
	4-Methyl-2-pentanone	0	56	0	39	1	18	0	18	4	5	5	136
	Acetone	18	56	4	39	4	18	2	18	2	4	30	135
	Benzene	1	56	5	39	0	18	0	18	2	3	8	134
	Bromodichloromethane	0	56	1	39	0	18	0	18	0	3	1	134
	Carbon Disulfide	2	56	1	39	2	18	2	18	2	3	9	134
	Chlorobenzene	0	56	1	39	0	18	0	18	0	3	1	134
	Chloroethane	0	56	3	39	0	18	0	18	1	3	4	134
	Chloroform	0	56	3	39	0	18	1	18	1	3	5	134
	Ethyl Benzene	3	56	0	39	4	18	0	18	3	4	10	135
	Methylene Chloride	12	56	7	39	2	18	1	18	2	4	24	135
	Styrene	1	56	0	39	0	18	0	18	1	3	2	134
	Tetrachloroethene	1	56	0	39	0	18	1	18	1	3	3	134
	Toluene	21	56	0	39	0	18	0	18	4	5	25	136
	Trichloroethene	2	56	3	39	0	18	1	18	3	3	9	134
	Vinyl Chloride	0	56	0	28	0	18	0	18	2	3	2	123
	Xylenes (Total)	5	56	0	39	5	18	1	18	4	5	15	136
SEMIVOLATILES	1,4-Dichlorobenzene	6	54	0	39	0	18	0	18	0	3	6	132
	2,4-Dimethylphenol	0	54	0	39	0	18	0	18	2	5	2	134
	2-Methylnaphthalene	1	54	0	39	0	18	0	18	0	3	1	132
	2-Methylphenol	0	54	0	39	0	18	0	18	2	5	2	134
	4-Methylphenol	0	54	0	39	0	18	0	18	2	5	2	134
	Acenaphthene	4	55	0	39	0	18	0	18	0	3	4	133
	Acenaphthylene	2	56	0	39	0	18	0	18	1	3	3	134
	Anthracene	5	56	0	39	0	18	0	18	0	3	5	134
	Benzo(a)anthracene	8	56	0	39	0	18	0	18	0	3	8	134
	Benzo(a)pyrene	8	56	0	39	0	18	0	18	1	3	9	134
	Benzo(b)fluoranthene	9	56	0	39	0	18	0	18	1	3	10	134
	Benzo(g,h,i)perylene	5	54	0	39	0	18	0	18	1	3	6	132
	Benzo(k)fluoranthene	9	56	0	39	0	18	0	18	1	3	10	134
	Benzoic acid	1	39	0	26	0	12	2	12	1	2	4	91
	Benzyl alcohol	0	39	0	26	0	12	0	12	1	2	1	91
	bis(2-Ethylhexyl)phthalate	32	54	10	39	0	18	8	18	2	4	52	133
	Butylbenzylphthalate	1	54	1	39	0	18	0	18	0	3	2	132
	Carbazole	3	17	0	12	0	6	0	6	0	1	3	42
	Chrysene	9	56	0	39	0	18	0	18	1	3	10	134
	Di-n-butylphthalate	10	56	0	39	0	18	1	18	0	3	11	134
	Di-n-octylphthalate	1	54	1	39	0	18	0	18	0	3	2	132
	Dibenzo(a,h)anthracene	4	56	0	39	0	18	0	18	0	3	4	134
	Dibenzofuran	3	56	0	39	0	18	0	18	0	3	3	134
	Diethylphthalate	0	54	3	39	0	18	1	18	1	4	5	133
	Dimethylphthalate	1	54	1	39	0	18	0	18	0	3	2	132
	Fluoranthene	10	56	0	39	0	18	0	18	1	3	11	134
	Fluorene	4	56	0	39	0	18	0	18	0	3	4	134
	Indeno(1,2,3-cd)pyrene	7	56	0	39	0	18	0	18	1	3	8	134
	Naphthalene	2	55	0	39	0	18	0	18	2	3	4	133

Table 2-3 - continued

FRACTION	CHEMICAL	SOIL Hits	SOIL Total	GROUNDWATER Hits	GROUNDWATER Total	SURFACE WATER Hits	SURFACE WATER Total	SEDIMENT Hits	SEDIMENT Total	TRENCH LEACHATE Hits	TRENCH LEACHATE Total	ALL MEDIA Hits	ALL MEDIA Total
	Phenanthrene	8	56	0	39	0	18	0	18	1	3	9	134
	Phenol	0	54	1	39	0	18	0	18	6	9	7	138
	Pyrene	10	56	0	39	0	18	0	18	1	3	11	134
PESTICIDES	4,4-DDE	1	56	0	38	0	15	0	18	0	5	1	132
	4,4-DDT	2	56	0	38	0	15	0	18	1	5	3	132
	Aldrin	0	56	0	38	0	15	0	18	2	5	2	132
	alpha-BHC	0	56	0	38	0	15	0	18	1	5	1	132
	alpha-Chlordane	0	56	0	38	0	15	0	18	1	5	1	132
	Aroclor-1248	0	56	0	38	0	15	1	18	0	5	1	132
	beta-BHC	0	56	0	38	0	15	0	18	2	5	2	132
	Dieldrin	0	56	0	38	0	15	0	18	1	5	1	132
	Endosulfan II	0	56	0	38	0	15	0	18	2	5	2	132
	gamma-Chlordane	0	56	0	38	0	15	0	18	2	5	2	132
	Heptachlor	0	56	0	38	0	15	0	18	2	5	2	132
INORGANICS	Aluminum, Dissolved			14	38	6	6					20	44
	Aluminum, Total	52	56	29	38	18	18	18	18	0	4	117	134
	Antimony, Dissolved			9	38	0	6					9	44
	Antimony, Total	25	56	10	38	0	18	1	18	2	4	38	134
	Arsenic, Dissolved			18	38	1	6					19	44
	Arsenic, Total	43	56	21	38	8	18	18	18	1	4	91	134
	Barium, Dissolved			36	38	6	6					42	44
	Barium, Total	47	56	37	38	18	18	18	18	0	4	120	134
	Beryllium, Dissolved			3	38	0	6					3	44
	Beryllium, Total	28	56	6	38	0	18	6	18	0	4	40	134
	Cadmium, Dissolved			1	38	1	6					2	44
	Cadmium, Total	1	56	4	38	0	18	0	18	2	4	7	134
	Calcium, Dissolved			38	38	6	6					44	44
	Calcium, Total	56	56	38	38	18	18	18	18	2	4	132	134
	Chromium, Dissolved			6	38	0	6					6	44
	Chromium, Total	44	56	15	38	2	18	18	18	4	4	83	134
	Cobalt, Dissolved			5	38	0	6					5	44
	Cobalt, Total	41	56	11	38	0	18	15	18	2	4	69	134
	Copper, Dissolved			7	38	0	6					7	44
	Copper, Total	51	56	21	38	1	18	18	18	0	4	91	134
	Iron, Dissolved			28	38	6	6					34	44
	Iron, Total	55	56	37	38	18	18	18	18	2	4	130	134
	Lead, Dissolved			15	34	3	6					18	40
	Lead, Total	51	56	18	36	12	18	18	18	2	4	101	132
	Magnesium, Dissolved			38	38	6	6					44	44
	Magnesium, Total	51	56	38	38	18	18	18	18	0	4	125	134
	Manganese, Dissolved			36	38	6	6					42	44
	Manganese, Total	54	56	38	38	18	18	18	18	0	4	128	134
	Mercury, Dissolved			2	38	0	6					2	44
	Mercury, Total	6	56	4	38	0	18	0	18	0	3	10	133
	Nickel, Dissolved			2	38	2	6					4	44
	Nickel, Total	36	56	9	38	2	18	17	18	1	1	65	131
	Potassium, Dissolved			35	38	6	6					41	44
	Potassium, Total	36	56	32	38	18	18	18	18	1	1	105	131
	Selenium, Dissolved			4	38	2	6					6	44
	Selenium, Total	12	56	9	38	0	18	11	18	0	1	32	131

Table 2-3 - continued

FRACTION	CHEMICAL	SOIL Hits	SOIL Total	GROUNDWATER Hits	GROUNDWATER Total	SURFACE WATER Hits	SURFACE WATER Total	SEDIMENT Hits	SEDIMENT Total	TRENCH LEACHATE Hits	TRENCH LEACHATE Total	ALL MEDIA Hits	ALL MEDIA Total
	Silver, Dissolved			5	38	0	6					5	44
	Silver, Total	5	50	8	38	1	18	1	18	0	1	15	125
	Sodium, Dissolved			38	38	6	6					44	44
	Sodium, Total	30	56	38	38	18	18	18	18	2	4	106	134
	Thallium, Total	0	54	0	38	1	18	1	12	0	4	2	126
	Vanadium, Dissolved			11	38	3	6					14	44
	Vanadium, Total	49	56	13	38	1	18	18	18	3	4	84	134
	Zinc, Dissolved			18	38	6	6					24	44
	Zinc, Total	45	56	23	38	12	18	18	18	0	4	98	134
	Cyanide, Total	6	56	0	30	0	18	0	18	2	4	8	126
OTHER	Bromide, Dissolved			20	26	3	12			3	4	26	42
	Chloride, Cl			25	25	12	12			4	4	41	41
	Nitrogen, Ammonia (NH3)			19	26	0	12			4	4	23	42
	Nitrogen, Nitrate + Nitrite (NO2 + NO3)			3	11	7	12					10	23
	Sulfate, SO4			22	25	12	12			0	4	34	41
	TP (Total Phosphorus)			11	12	12	12			2	2	25	26

health (NAS 1989). Hence, these essential nutrients detected may not be of concern to human health. The average detected concentration of these chemicals in surface soil and groundwater was used to estimate a maximum daily intake of these chemicals, based on an assumed intake of 120 mg/day of soil and 2 L/day of water. If the estimated intake of a chemical (mg/day) from both soil and water did not exceed the Recommended Dietary Allowance (RDA) for an adult (>18 years old) (NAS 1989), the chemical was eliminated as a chemical of potential concern. Calcium, copper, magnesium, manganese, potassium, selenium, sodium and zinc were thus eliminated as chemicals of potential concern (see Table 2-4). The only essential nutrient retained is iron.

Tentatively Identified Compounds

A number of tentatively identified compounds (TICs) were reported in the database (see Table A1-6). For TICs the identities of these chemicals assigned by the laboratory may be inaccurate. In addition, the concentrations reported are highly uncertain. In general, TICs are not evaluated quantitatively. Eliminating TICs from the risk evaluation is a source of some uncertainty in the risk assessment. This is discussed in Section 6.0 of this report.

2.4 Summary of Chemicals of Potential Concern

After excluding chemicals never detected, essential nutrients and TICs, the chemicals remaining are considered chemicals of potential concern for the Himco Dump site. These chemicals are listed in Table 2-5.

Appendix 1 provides the sampling results for all the chemicals at locations on site or potentially impacted by site contaminants including frequency of detection, ranges of detected concentrations and the range of detection limits. Also included are the sampling results at all background locations. Table A1-3 includes results for soil samples at all four background locations at all depths 02, 04, 05, 06).

It should be noted that exclusion of a chemical because it was never detected may introduce some uncertainty into the risk assessment. This is especially true if the detection limit was sufficiently high (i.e., insensitive) such that a health risk might occur at levels equal to or less than the detection limit. The uncertainty introduced by exclusion of never detected chemicals is discussed in Section 6.0.

TABLE 2-4 EVALUATION OF ESSENTIAL NUTRIENTS

Chemical	Concentration in Soil, mg/kg[a]	Daily Intake from Soil, mg/day[b]	Concentration in Water, mg/L[c]	Daily Intake from Water, mg/day[d]	Total Daily Intake, mg/day	RDA,[e] mg/day
Calcium	1.2E+5	1.4E+1	1.2E+2	2.4E+2	2.5E+2	1.2E+3
Copper	3.2E+1	3.8E-3	2.0E-2	4.0E-2	4.4E-2	3.0E+0[f]
Iron	4.7E+3	5.6E-1	1.1E+1	2.2E+1	2.2E+1	1.5E+1
Magnesium	4.4E+3	5.3E-1	2.6E+1	5.2E+1	5.3E+1	3.5E+2
Manganese	1.3E+2	1.6E-2	4.7E-1	9.4E-1	9.6E-1	5.0E+0[f]
Potassium	2.2E+2	2.6E-2	5.7E+0	1.1E+1	1.1E+1	2.0E+3[f]
Selenium	7.2E-1	8.6E-5	4.1E-3	8.2E-3	8.3E-3	7.0E-2
Sodium	6.0E-01	7.2E-3	3.5E+1	7.0E+1	7.0E+1	5.0E+2[f]
Zinc	4.4E+01	5.3E-03	1.1E+0	2.2E+0	2.2E+0	1.5E+1

(a) Upper 95th confidence limit of the arithmetic mean of all surficial soil samples.
(b) Daily intake based on an assumed ingestion of 120 mg soil/day, time weighted for child and adult exposures (USEPA 1991c).
(c) The maximum detected concentration in groundwater samples.
(d) Daily intake based on an assumed ingestion of 2 L/day.
(e) Recommended Dietary Allowance (RDA) based on an individual >18 yrs old (NAS 1989).
(f) Minimum requirements of healthy persons.

TABLE 2-5 CHEMICALS OF POTENTIAL CONCERN - HIMCO DUMP SITE

INORGANICS:

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Cobalt
Iron
Lead
Mercury
Nickel
Silver
Thallium
Vanadium
Cyanide

ORGANICS:

VOLATILES

1,1-Dichloroethane
1,1-Dichloroethene
1,1,1-Trichloroethane
1,2-Dichloroethene
2-Butanone
2-Hexanone
4-methyl-2-pentanone
Acetone
Benzene
Bromodichloromethane
Carbon disulfide
Chlorobenzene
Chloroethane
Chloroform
Ethylbenzene
Methylene chloride
Styrene
Tetrachloroethene
Toluene
Trichloroethene
Vinyl chloride
Xylenes

SEMIVOLATILES

1,4-Dichlorobenzene
2,4-Dimethylphenol
2-Methylnaphthalene
2-Methylphenol
4-Methylphenol
Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(g,h,i)perylene
Benzoic Acid
Benzyl alcohol
bis(2-Ethylhexyl) phthalate
Butylbenzylphthalate
Chrysene
Carbazole
Dibenzofuran
Dibenz(a,h)anthracene
Diethylphthalate
Dimethylphthalate
Di-n-butylphthalate
Di-n-octylphthalate
Fluoranthene
Fluorene
Indeno(1,2,3-cd) pyrene
Naphthalene
Phenanthrene
Phenol
Pyrene

PESTICIDES/PCB's

4,4'-DDT
4-4'-DDE
Aldrin
alpha-BHC
alpha-Chlordane
beta-BHC
Dieldrin
Endosulfan II
gamma-Chlordane
Heptachlor
Polychlorinated biphenyl - Aroclor 1248

NON-CLP CHEMICALS:

Bromide, dissolved
Chloride
Nitrogen, ammonia
Nitrogen, nitrate & nitrite
Phosphorus
Sulfate

3.0 EXPOSURE ASSESSMENT

Exposure is defined as the contact between a human and a chemical in the environment. The amount of contact (the dose) depends upon the level of the chemical in the environment and the extent of contact between humans and contaminated media. The exposure assessment presented in this section describes the pathways by which humans may be exposed to chemicals of potential concern at the Himco Dump Site and provides quantitative estimates of dose for the most important of these pathways.

3.1 Characterization of the Exposure Setting

This section summarizes site information with respect to the physical characteristics and characteristics of the populations (both current and hypothetical future) on and near the site. The source of the following information includes data collected by SEC Donohue Inc. during the RI process, the Soil Conservation Service, the U.S. Geological Survey, the U.S. Census Bureau, a site visit conducted by Life Systems, Inc. personnel in October 1990 and city and county maps of the area.

3.1.1 Physical Setting

The Himco Dump site is a closed landfill located at County Road 10 and the Nappanee Street Extension in the Town of Elkhart in Elkhart County, Indiana. The site is approximately 50 acres and is bounded on the east by Nappanee Street Extension, on the south by County Road 10 and private residences, on the west by a tree line and an "L"-shaped pond and on the north by a tree line and a quarry pit pond (Figure 1-2). Approximately two-thirds of the site has been landfilled.

Climate

Elkhart County has a typical mid-continental climate with large temperature variations between summer and winter. The average monthly temperature in Elkhart County ranges from 23 F in January to 72 F in July. The temperature extremes are from 10 F to 98 F. The mean annual rainfall and snowfall are 34.5 and 36 inches, respectively. Snowfall normally occurs from November to March (SEC Donohue 1992).

Meteorology

The wind rose from the South Bend/St. Joe weather station (approximately 15 miles from Elkhart) is shown in the lower right-hand corner of Figure 1-2. This indicates the prevailing wind direction is from the southwest. The average windspeed is 5.03 mph (GSC 1989).

Geologic Setting

The site is within an area that has been glaciated four times during the Pleistocene Epoch. After each glaciation, the ice receded and melt-water streams eroded the glacial deposits. As a result, the bedrock is covered with stratified and unstratified drift.

The surficial geology is characterized by valley train outwash deposits (average thickness of 175 feet) bounded on the north and south-southeast by till plains of stratified drift and ground-moraine deposits. The till deposits in the area consist of silty sand interbedded with clay and silt layers. No indication of this silt and clay layer, however, was detected beneath the site. The bedrock geology consists of Devonian and Mississippian shales. Depth to shale ranges from 85 to 500 feet and averages 175 feet (USGS 1981, Donohue & Associates 1990a, Donohue & Associates 1991c).

Soil Type

The principal soils on site are the Tawas Muck (present in the center to southeastern quadrant of the Site) and the Plainfield Fine Sand (present in the northeast quadrant and south central area of the site). The Tawas Muck is a poorly drained soil with rapid permeability, high organic matter content and high available water for plant growth. The Plainfield Fine Sand is a rapidly drained, highly permeable sand with a high content of organic matter and low available water for plant growth (SEC Donohue 1992).

Other soils on site include the Tyner Loamy Sand, the Gilford Sandy Loam and the Oshtemo Loamy Sand. The sands are somewhat excessively drained with rapid permeability and low available water for plant growth. The loam is very poorly drained with rapid permeability and has moderate available water for plant growth (USDA 1989).

Surface Water Hydrogeology

The site is located in the St. Joseph River basin. The river is approximately two miles south of the site. The St. Joseph River flows east to west ultimately into Lake Michigan at St. Joseph, Michigan.

A portion of the site was originally a marsh that has been filled with various wastes (Donohue & Associates 1990a). Three surface water bodies have been excavated on site and have been likely filled by precipitation, surface runoff and possibly, groundwater discharge.

A surface water runoff analysis determined that the site has two primary drainage areas, which divide the site in approximately two halves from northwest to southeast (Donohue & Associates 1991a). The approximate eastern section of the site drains to the quarry pit pond and the approximate western section of the site drains to the other two ponds and off site to the west and to a lesser extent, to the northwest. The ponds on the western section of the site would overtop in a 100-year flood event and flow to the west.

Description of Surface Water Bodies

The largest surface water body is the quarry pit pond located in the northeast corner of the site. It is approximately 550 by 850 feet. The shoreline and bottom are generally sand and gravel. The larger of the other two ponds is "L"-shaped with the longer channel oriented north-south and the shorter channel oriented east- west. Each channel is approximately 100 feet wide and

400 feet long. The smallest of the three surface water bodies is located directly northeast of the "L"-shaped pond and is approximately 100 by 170 feet. The shorelines and bottoms of the two smaller ponds are sand and gravel (Donohue & Associates 1991d). Within a one-mile radius of the site, located directly south of the site, are four additional quarry pit ponds.

Groundwater Hydrogeology

Groundwater flow is generally southeast toward the St. Joseph River which is a regional discharge. The saturated zone has a high hydraulic conductivity with a low vertical and horizontal gradient, implying that pumping of wells would have a significant effect on the groundwater (and contaminant) flow direction. Deep pumping would increase the vertical gradient, thereby causing the groundwater (and contaminants) to migrate downward. Groundwater occurs between 5 and 20 feet below the site at elevations from 752 to 756 mean sea level (MSL) within the sand and gravel outwash deposits. (The elevation of the waste mass is 755 to 760 feet MSL.) The aquifer is unconfined below the site and the approximate saturated thickness of the aquifer ranges from 40 to 450 feet in the region (Donohue & Associates 1990b, 1991c, 1991e).

Virtually all residences and businesses south of the Himco Dump are connected to the municipal water supply. There is one residence at 28498 County Road 10 (south and west of the site) where a drinking water well is presently in use. This well was sampled in May 1992 and no contamination was detected (Steadman 1992). It would appear that this well is too far west to be considered downgradient. The municipal well field is located approximately a mile and a half south of the site (Main Street Well Field). Residences and businesses east and southeast of the site utilize private water wells.

Vegetation

The amount and composition of the vegetation varies across the site. Two known barren areas of sand and/or calcium sulfate exist south of the quarry pit pond and north of the lower channel of the "L"-shaped pond. A mixed deciduous and nondeciduous forest surrounds the quarry pit pond and the remainder of the site is a mix of grass, low vegetation, shrubs and trees. In the past, soybeans were grown on the western half of the site. Additional details on site vegetation are included in the Environmental Evaluation prepared for the site (Life Systems 1992).

Wetlands

The only wetland on site is located directly south of the east portion of the quarry pit pond. The wetland is approximately 2,500 square feet in size (less than one-half acre). The areas surrounding the other surface water bodies (and sampled as suspected wetland areas) are not considered jurisdictional wetlands nor what would be typically considered "wetlands" as defined by current wetland description criteria (Donohue & Associates 1991g). The soil, vegetation and hydrogeology of the areas are not characteristic of wetlands.

3.1.2 Potentially Exposed Populations

Current Populations/Land Uses

The city of Elkhart has a population of 43,627 (USDC 1990) and covers approximately 17 square miles. Within a one-mile radius there are a variety of land uses, including residential, commercial, industrial and agricultural. At one time approximately one-third of the site was used for soybean production.

No one currently resides or works on the site. However, on-site visitors have been observed engaging in recreational activities such as hunting and dirt-bike riding[(a,b)]. Other similar activities could potentially include playing, walking, fishing, wading and swimming.

There are residences near the site (east, west, south and southeast) and industrial and commercial properties southeast of the site (Figure 1-2). The residences located east of the site are downwind and side-gradient (with respect to groundwater flow); residents and workers south of the site are upwind and downgradient.

Future Populations/Land Uses

Several hypothetical future land uses are possible, but may not be technically and/or financially reasonable. Possible future scenarios include development of residences or commercial/industrial properties on site. The composition of the natural soils in combination with the shallow water table and fill material would make construction on the site difficult and potentially costly. Construction along the perimeter of the site (not on the landfill) would be more feasible. Other hypothetical future land uses include both recreational or agricultural. The site could revert back to cropland (e.g., a soybean field) or be developed as for outdoor recreational activities (e.g., a park). Therefore, hypothetical future on-site populations could include residents, industrial workers, agricultural workers and recreational populations.

If development is limited or does not occur, it is anticipated that future recreational activities would be similar to current recreational activities.

3.1.3 Potentially Sensitive Subpopulations

Sensitive subpopulations are groups or individuals who may be more sensitive to chemical exposures in general because of their age or health status (USEPA 1989a). No groups of specific sensitive subpopulations (e.g., nursing homes, hospitals, schools) are located near the site.

(a) Personal conversation between Marcia Kuehl and Donna Studniarz, May 9, 1991.

(b) Personal conversation between Steve Padovani and Donna Studniarz, May 9, 1991.

3.2 Identification and Analysis of Complete Exposure Pathways

An exposure pathway describes the movement of a chemical from a source to the point where an individual comes in contact with that chemical. A complete exposure pathway consists of the following:

- A source and mechanism of chemical release
- A transport medium
- A point of potential contact with the contaminated medium
- An exposure route at the contact point
- A potentially exposed population

A complete pathway generally contains all these elements. In some instances, the source is also an exposure point and there is no release or transport involved. If a pathway is not complete, there is no exposure and therefore risk cannot be characterized.

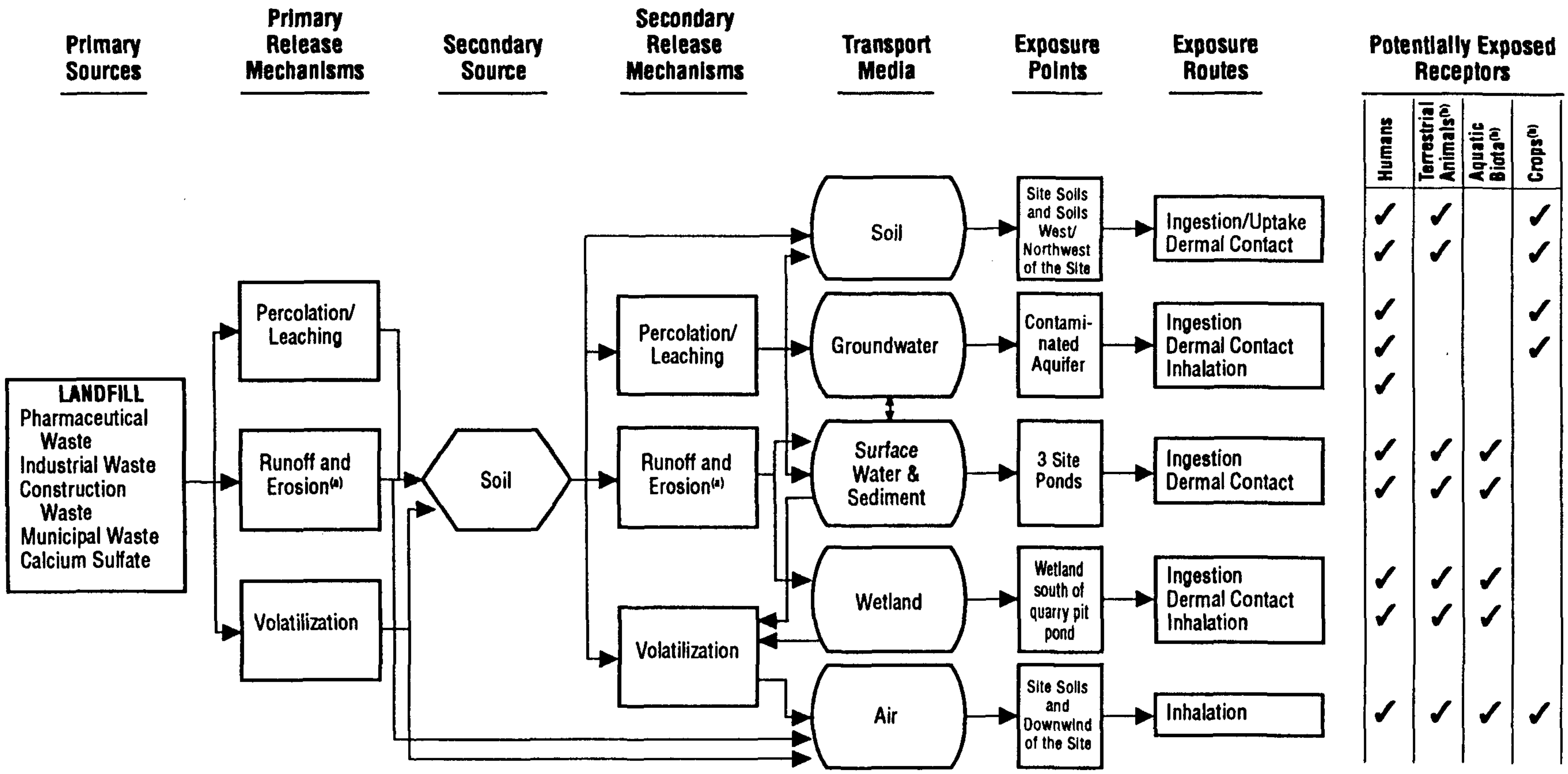
The information available for the Himco Dump site was evaluated to determine which exposure pathways are complete. To illustrate the exposure pathways from sources to receptors, a conceptual site model was developed and is illustrated in Figure 3-1. The elements of this model are described in more detail below. All possible and reasonable exposure pathways are first identified and evaluated for completeness and exposure pathways are then selected for quantification.

Identifying complete exposure pathways involves not only characterizing site features but must also take into consideration physical and chemical properties of the site contaminants. Predicting the fate and transport of all the chemicals of potential concern from their source at Himco to receptors at an exposure point is difficult on a chemical-by-chemical basis. However, some assumptions can be made by assuming classes of similar compounds behave similarly. More detailed information on site fate and transport is included in the RI Report (SEC Donohue Inc. 1992). This information has been taken into consideration in the following pathway analyses.

3.2.1 Identification of Exposure Pathways

Sources, Release Mechanisms and Transport Media

The Himco Dump is an uncontrolled landfill without a liner or recovery systems for leachate or gas. The wastes were landfilled directly on to the ground surface across the site and in trenches. Reportedly, paper wastes were dumped and burned in the trenches. The landfilled area was covered on a regular basis with sandy soil from the quarry pit, excavated ponds and any source around the site perimeter. Wastes consisted primarily of calcium sulfate sludge and to a lesser extent, pharmaceutical, industrial, construction and municipal wastes. When the landfill closed in 1976, a cover of calcium sulfate and sand was laid over the wastes. These landfilled wastes are the primary sources of contamination. Once buried, wastes can travel through the vadose zone to groundwater (via percolation) or volatilize into the atmosphere.



(a) Includes wind erosion and mechanical (e.g. vehicular) erosion.
(b) Terrestrial animals, aquatic biota and crops may be secondary or tertiary sources for human receptors.

FIGURE 3-1 CONCEPTUAL SITE MODEL

Percolation, leaching, runoff and erosion are all possible transport mechanisms. The rate of this transport is dependent on groundwater velocity as well as the properties of the chemicals themselves (solubility, dispersity, adsorption, etc.). Nearly every chemical detected in soil was also detected in groundwater or leachate water. Concentrations of volatiles in soil generally increase with depth. The highest concentrations are in subsurface soil followed by groundwater. Although this pattern is not consistent with the inorganics, all inorganics detected in soil were detected in groundwater (with the exception of cyanide). Thus, the data generally support the movement of wastes to the groundwater.

The sand and calcium sulfate cover is insufficient to prevent migration of contaminants. The cover is also not consistently thick enough (it thins west to east and is nonexistent in some areas) to prevent potential migration of volatile contaminants or fugitive dust emissions (from wind or mechanical/ vehicular erosion) to the atmosphere (Donohue & Associates 1991h).

The contaminants in groundwater were detected in both shallow and deep wells, indicating an unconfined aquifer (SEC Donohue 1992). The contaminants appear to be diluted by recharge events and have moved into the aquifer (Donohue & Associates 1991c). Currently, residences immediately south of the site are all on city water. There is one drinking water well in use located south of County Road 10. This residence appears to be far enough west of the site to be unaffected by off-site contaminant migration. Residents east of the site are located outside of the city limits and do draw from the aquifer. Groundwater drawn from these wells was determined to be unaffected by site contaminants (Donohue & Associates 1991b).

The USGS identified a bromide plume originating from the site and migrating away from the site in a south-southeasterly direction (Appendix E, Donohue & Associates 1990a). The plume had extended less than a mile from the site in USGS studies through 1987 (Donohue & Associates 1990a). The extent of the plume appears constant and the concentrations are gradually decreasing (Donohue & Associates 1990a).

It is unlikely that contaminants will migrate to the Main Street wellfield (the source of drinking water for the city of Elkhart, approximately 1-1/2 miles to the southeast) and if so, would be diluted by a factor of 10^6.[a] Based on the above information, it is unlikely significant levels of contaminants would migrate to the St. Joseph River.

Surface soil and subsoil are secondary sources of contaminants. An important intermedia transfer mechanism is percolation of precipitation and contaminant leaching, which can lead to transport of contaminants from soil to groundwater to surface water bodies and the wetland area. Contaminants in soil can also impact the three surface water bodies and the wetland area by erosion and surface runoff (Donohue & Associates 1991a). The data however, do not clearly support the transport of soil contamination to the surface water.

(a) Personal conversation between Vanessa Harris and Donna Studniarz, June 25, 1991.

Leachate water was observed and sampled from several test pits. This leachate water was primarily found at elevations above the water table and is suspected to be from perched locations within the landfill waste (SEC Donohue Inc. 1992). The RI also concluded that groundwater is in contact with the waste. Contaminants detected in leachate waste may, therefore, be a source of groundwater contamination.

Contaminants in soil, surface water, sediment and the wetland area could also potentially bioaccumulate in aquatic biota (e.g., fish) or be ingested by terrestrial animals, which would become secondary or tertiary sources of contaminants. Bioaccumulation can be predicted by evaluating a chemical's water solubility and octanol water partition coefficient (K_{ow}). Chemicals that are highly soluble (>1,000 ppm) with a K_{ow} <500 are considered negligible bioaccumulators (Ney 1990). Of the organic chemicals detected in surface water, only ethylbenzene would be expected to bioaccumulate, but it is not considered a strong bioaccumulator.

Crops grown on or off site could potentially be affected by site contaminants via irrigation with groundwater contaminated by the site.

Exposure Points

An exposure point is defined as that point where a human can come in contact with a contaminated medium. The contaminated source, transport medium or release point itself can also be an exposure point (e.g., contaminated surface soil). Current exposure points identified for the Himco Dump site include:

- On-site surface soil
- Surface water and sediments in/around the quarry pit pond, the "L"-shaped pond and the other small pond
- Wells south of the site
- Surface soil west and northwest of the site
- Residences located downwind of the site (northeast)

Additional hypothetical future exposure points include:

- Site subsoil
- Hypothetical well drilled on site
- Hypothetical well impacted by site contaminants drilled southeast of the site

Exposure Routes

Human populations may be exposed to contaminants by the following three routes: (1) ingestion of contaminated media, (2) inhalation of contaminated media and (3) dermal contact with contaminated media.

Based on the nature of contamination and the anticipated activities at the exposure points, exposure routes identified as likely at the Himco Dump site include the following:

- Ingestion and dermal contact with soils
- Ingestion and dermal contact with groundwater
- Inhalation of volatiles released from groundwater uses within a home
- Ingestion and dermal contact with surface waters and sediments
- Inhalation of volatile and/or particulate emissions from site soils, surface water and sediments
- Ingestion of contaminated crops or animals (e.g., aquatic or terrestrial)

3.2.2 Complete Exposure Pathway Analysis

The exposure pathways judged complete for current and hypothetical future land uses are listed in Tables 3-1 and 3-2. Potential pathways that are judged to be incomplete (e.g., no exposure point and/or route by which contact could occur) are not quantified. From all the complete exposure pathways at the site, some pathways were eliminated for quantitative analysis based on one or more of the following reasons:

- The exposure resulting from the pathway is judged likely to be substantially less than that from another pathway involving the same population and the same medium (e.g., inhalation of particulates while walking on site compared to inhalation of particulates while dirt-bike riding on site).
- The potential magnitude of exposure to a population is considerably less than that of another population by a similar pathway (e.g., exposure of upwind residents to airborne particulates is substantially less than exposure to downwind residents via the same pathway).
- The probability of the exposure occurring is very low. For example, ingestion of fish is considered a pathway of low exposure potential since both the contaminant levels are low and the associated exposure duration and frequency are very low.
- The necessary data to quantify a pathway are not available and cannot be reliably estimated (e.g., concentration of contaminants in crops).

The justifications for not quantifying pathways are summarized in Tables 3-1 and 3-2. More detail on several of these rationales is provided below.

TABLE 3-1 POTENTIALLY COMPLETE EXPOSURE PATHWAY SUMMARY - CURRENT LAND USE

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Pathway Selected for Quantitative Evaluation?	Reason for Selection or Exclusion
Residents in homes immediately south of the site	Ingestion of groundwater from a well downgradient of site, inhalation of volatiles released from groundwater into household or dermal exposure to groundwater during showering or bathing	No	Residents immediately south of the landfill are currently on city water, although there is no prohibition against use of these drinking water wells.
	Inhalation of volatiles or contaminated airborne particulates from the site	No	Residence is upwind and exposure is likely to be less than a downwind resident.
	Visiting the site to dirt-bike, walk, fish, swim or hunt may result in potential exposure to site contaminants via ingestion and direct contact with soils, surface water, sediments and consumption of contaminated fish and terrestrial animals	No	A separate recreational population is evaluated. These residents assumed to have similar or lower exposures.
Residents east/north east of the site	Inhalation of contaminated airborne particulates from the site	Yes	Residences are downwind of the site
	On-site recreational exposure scenarios (described above for the residents south of the site)	No	A separate on-site recreational population is evaluated. These residents assumed to have similar or lower exposures.

continued-

Table 3-1 - continued

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Pathway Selected for Quantitative Evaluation?	Reason for Selection or Exclusion
Residents west/north west of the site	On-site recreational scenarios (described above)	No	A separate recreational population is evaluated. These residents assumed to have similar or lower exposures
Recreational visitors on site	Visitors on site are assumed to engage in recreational activities potentially resulting in the following exposures:		
	• Inhalation of airborne particulates while dirt-bike riding on site	Yes	Dirt-bike riding has been observed on site
	• Inhalation of volatiles while dirt-bike riding on site	Yes	Dirt-bike riding has been observed on site
	• Ingestion of soil while dirt-bike riding on site	Yes	Dirt-bike riding has been observed on site
	• Ingestion of surface water and sediment while fishing or wading in site ponds	Yes	Children may ingest surface water and sediment while fishing and wading in ponds on site
	• Dermal contact with surface water	Yes	Children may contact surface water while fishing and wading in ponds on site

continued-

Table 3-1 - continued

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Pathway Selected for Quantitative Evaluation?	Reason for Selection or Exclusion
Recreational visitor (continued)	• Dermal contact with sediments	No	Cannot be reliably estimated.
	• Consumption of fish caught in a pond on site	No	Detected chemicals not strong bioaccumulators, fish supply not large enough to be considered a reasonable food source. (see text)
	• Consumption of animal meat (i.e., deer) from hunting on site	No	Unable to quantify reasonably with available data.
	• Other exposure pathways from potential recreational activities (i.e., inhalation of particulates while walking, ingestion of dirt while picnicking, etc.)	No	The potential magnitude of these exposures is considerably less than that from the above exposures via the same routes.

TABLE 3-2 POTENTIALLY COMPLETE EXPOSURE PATHWAY SUMMARY - FUTURE LAND USES

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Pathway Selected for Quantitative Evaluation?	Reason for Selection or Exclusion
Residents on site	Ingestion of contaminated soil while playing or gardening	Yes	Residential development of the site is possible, more probably along the perimeter in the south-eastern section of the site. Residence on landfill itself not as likely, but nonetheless also evaluated.
	Inhalation of contaminated particulates via mechanical or wind erosion from soil	Yes	Pathway complete if development occurs on landfill area.
	Inhalation of volatiles from soil	Yes	Pathway complete if development occurs on landfill area.
	Inhalation of landfill gases	No	Even if development occurred on site, construction of a house with a basement is extremently unlikely. Data not available to quantify pathway.
	Consumption of produce grown on site	No	Unable to quantify with available data (see text).

continued-

Table 3-2 - continued

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Pathway Selected for Quantitative Evaluation?	Reason for Selection or Exclusion
Residents on site (continued)	Ingestion of contaminated surface water and sediment while fishing or wading in surface water bodies on site and inhalation of contaminated particulates and ingestion of surface soil from dirt-bike riding	No	Exposure is assumed to be similar to a current recreational visitor.
	Ingestion of groundwater from a well drilled on site, inhalation of volatiles released from groundwater into household air, dermal exposure to groundwater during bathing or showering	Yes	It is assumed residents may drill a drinking water well on site.
	Other exposure pathways (i.e., ingestion of particulates while walking, ingestion of soil while bicycling, etc.)	No	Magnitude of exposure is low in comparision to above pathways via the same exposure route.
Occupational Workers on site	Ingestion of contaminated soil	Yes	Reasonable potential exposure, although commercial development more likely south of the landfill rather than on the landfill area itself.
	Inhalation of volatiles and contaminated particulates from soil	Yes	Same as above
	Ingestion of groundwater from well drilled on site	Yes	Assumption that the facility may drill a drinking water well is reasonable.

continued-

Table 3-2 - continued

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Pathway Selected for Quantitative Evaluation?	Reason for Selection or Exclusion
Agricultural Workers on site	Ingestion of contaminated soil	Yes	Future agricultural use possible, exposure frequency and potential could be significant.
	Inhalation of volatiles from soil and contaminated particulates from wind or mechanical erosion	Yes	Exposure to volatiles and airborne particulates is possible while working in the field.
	Ingestion of groundwater from well drilled on site	Yes	It is assumed drinking water may be from a well drilled on site.
Recreational visitor	Exposure routes, media and exposure points similar to those described for a current recreational visitor	No	Exposure assumed to be similar to current recreational visitor.
Off-site resident north/northeast of the site	Inhalation of volatiles and contaminated particulates from the site assuming agricultural development	Yes	Reversion to agricultural use possible.
	All other potential exposure pathways	No	Exposure frequency and duration would be similar or lower than for other populations with the same exposure routes.

Ingestion of Crops. A portion of the site has previously been used for crops and nearby residents do have vegetable gardens.[a] However, quantifying this pathway would require considerable data that are not available: concentrations of contaminants in garden soil (considering any additions of soil enhancers or fertilizers), types and quantities of vegetables grown, quantitative estimates of uptake of contaminants by those vegetables and quantitative estimates of the amount of home-grown or site-grown produce consumed by an individual. Therefore, this pathway was not quantified. The uncertainty contributed by the lack of quantification of this pathway is discussed further in Section 6.0 of this report.

Ingestion of Fish

Although there is evidence that fishing occurs at the three surface-water bodies it is not certain that any fish caught are actually consumed. The ponds are not large enough to produce a consistent supply of edible-size fish that would be a reliable food source. Therefore, this pathway was not quantified.

Dermal Contact with Soil or Sediments

Dermal contact with soil or sediments could be a route of exposure at this site. However, quantification of dermal exposure via soil contact is extremely uncertain due to lack of data on the rate of chemical absorption from soil across the skin (USEPA 1992a). Therefore this pathway was not quantified.

Table 3-3 summarizes the pathways selected for quantitation.

3.3 Quantification of Exposure

The magnitude of human exposures to chemicals is usually expressed in terms of the average daily intake (DI), which is the amount of chemical in contact with a body exchange surface (skin, lungs, gastrointestinal track). To calculate intakes, the following general equation is used:

$$I = C \times \frac{CR \times EFD}{BW} \times \frac{1}{AT} \qquad (1)$$

where:

- I = Intake; the average amount of the chemical at the body's exchange boundary (mg/kg-day).
- C = Chemical concentration; the average concentration which comes in contact with the body during the exposure period at the exposure point (mg chemical/unit of environmental medium).
- CR = Contact Rate; the amount of contaminated medium contacted per unit time or event (e.g., L/day for drinking water).

(a) Observation by Life Systems, Inc. personnel Jo Ann Duchene and Michael Kangas during a site visit in October 1990.

TABLE 3-3 SUMMARY OF EXPOSURE PATHWAYS SELECTED FOR QUANTIFICATION

Land Use	Potentially Exposed Population	Exposure Point	Exposure Medium	Exposure Route
Current	Dirt-bike rider	Site	Soil Air	Ingestion Inhalation - Particulates - VOCs
	Wader	Surface water on site (ponds or quarry pit)	Surface water Sediment	Ingestion Dermal contact Ingestion
	Residents (child and adult) northeast of site	Closest downwind residence northeast of site	Air	Inhalation - Particulates - VOCs
Hypothetical Future	Residents (child and adult)	Residence on landfill or south of landfill area	Soil Groundwater	Ingestion Ingestion Inhalation-VOCs Dermal
	Workers	Plant or office facility on landfill or south of landfill area	Soil Groundwater	Ingestion Ingestion
	Agricultural Workers	On landfill area	Soil Air Groundwater	Ingestion Inhalation - Particulates - VOCs Ingestion
	Residents (child and adult) northeast of site	Closest downwind residence northeast of site (assuming future agricultural development)	Air	Inhalation - Particulates - VOCs

EFD = Exposure Frequency and Duration (how long and how often exposure occurs). The EFD term is usually calculated using two terms, the exposure frequency (EF) (usually expressed days/year) and exposure duration (ED) (usually expressed in years).

BW = Body Weight; the average body weight over the exposure period (kg).

AT = Averaging Time; period over which exposure is averaged (days).

In general, the values of C and the remaining exposure factors can depend on time. Therefore, it is necessary to calculate intakes for subchronic (14 days to 7 years), chronic (7 years or more) or lifetime (70 years) exposure periods.

The variables in this equation are chosen so that an estimate of the reasonable maximum exposure (RME) for each pathway is achieved (USEPA 1991c, USEPA 1989a). The RME is defined as the maximum exposure that is reasonably expected to occur (USEPA 1989a).

This step is undertaken in two stages: estimation of exposure concentrations (the "C" term in the equation) and calculation of human intake factors (HIFs) (the "CR," "EFD," "BW" and "AT" terms).

3.3.1 Estimation of Exposure Point Concentrations

An exposure point concentration is the arithmetic mean concentration of a chemical in a medium, averaged over the area within which exposure is expected to occur (USEPA 1989a). Although this concentration is usually not the maximum concentration that could potentially be contacted at any one time, it is regarded as a reasonable estimate of the concentration that is likely to be contacted over time. Because of the uncertainty associated with estimating the true arithmetic mean from a limited number of samples, a degree of conservatism is needed in calculating exposure point concentrations (USEPA 1989a). This conservatism is provided by using the upper 95th confidence limit of the arithmetic mean (AM_{95}).

The concentration of a chemical in the environment may not be constant over time, but may tend to decrease due to volatilization, degradation or migration. When data permit, it is therefore advisable to obtain concentrations of the chemicals of concern to allow for time trends. At the Himco site there is no available quantitative information regarding this, therefore, concentration values are assumed to remain constant over the next thirty years (the maximum exposure duration evaluated).

Calculation of exposure point concentrations is sometimes complicated by the presence of nondetects in the data set, the small number of data points at a given exposure point or large variation among sample results. In calculating exposure point concentrations for this site, the following rules were employed:

- If a chemical was not detected in any of the samples used for the exposure point concentration calculation, it was assumed to be absent (i.e., the exposure point concentration was taken to be zero). There were several exceptions to this rule as detailed below.

- If a chemical was detected in soil anywhere on site, but not detected in any groundwater sample, the AM_{95} was calculated using one-half the detection limit. This reflects the assumption that the soil serves as a source of contamination to the groundwater.

- If a polycyclic aromatic hydrocarbon (PAH) was detected only in soil it was assumed to be absent (at zero) in any groundwater exposure point concentration calculation. This reflected the assumption that PAHs in general are not mobile and are not expected to migrate from soil to groundwater.

- If a chemical was detected in at least one groundwater sample but not within the particular wells selected to represent a given exposure point, the AM_{95} was calculated assuming this chemical was present at one-half the detection limit.

- In any data set for a given exposure point if a chemical was detected at least once, the nondetects for that chemical were evaluated at one-half the reported detection limit.

- If the AM_{95} in any calculation exceeded the highest detected value, then the maximum detected value, rather than the AM_{95} was used as the exposure point concentration.

Calculations of exposure point concentration for each medium are detailed below.

Groundwater

For all hypothetical future site development, it is assumed that a well is drilled on site either through the waste mass of the landfill or in the southeastern section of the site. In accordance with guidance (USEPA 1991a, USEPA 1989a), the exposure point should be selected to represent the center of the contaminant plume. There does not appear to be a well defined plume. Therefore, the exposure point concentration for future hypothetical groundwater within the waste mass was approximated by using the leachate water samples (with the exception of TL-05) and the wells located on the perimeter of the waste mass. The leachate waste sample from TL-05 was a biphasic sample containing almost 50% toluene and a variety of other volatile organic compounds. This sampling area was the location of the removal activity which occurred in May 1992. Therefore, sample TL-05 was not used since it is not representative of the aquifer quality. Use of this sample in an AM_{95} calculation would result in a skewed exposure point concentration, which would be extremely unreasonable.

To approximate the contaminant concentration in the area south of the landfill, wells in that area were used. Wells further down gradient or side gradient were excluded. For these residential scenarios shallow and deep wells were evaluated separately. If the site were commercially developed a shallow well was judged to be insufficient, therefore, only a deep well was evaluated for a future commercial land use.

Surface Water and Sediment

The wader is assumed to fish and play/wade on site either by the quarry pit pond or the two smaller ponds in the southwestern section of the site. Therefore, the exposure point concentrations for exposure to the quarry pit pond include all surface water and sediment samples in the quarry pit pond and for exposure to the two smaller ponds, all surface water and sediment samples associated with the two smaller ponds.

Soil

Two future hypothetical residential/commercial development exposure points were evaluated. It is extremely unlikely that construction of a house or commercial plant would occur on the waste mass (landfilled) areas of the site due to structural and economic considerations. Nonetheless, this exposure point was evaluated utilizing surface soil samples taken from the landfill cap. Development would more likely occur south of the landfilled area. This assumption is supported by the presence of residences just off site to the west and east. The exposure point concentration for this scenario utilized soil samples taken this area. The hypothetical future agricultural scenario was quantified assuming the landfilled area would revert to crops.

The dirt bike riders were assumed (and observed) to ride in general across the landfilled area and just south of it. The samples used in the exposure point calculation utilized surficial soil samples from the landfill area, the dirt bike trail just south of the quarry and samples just south of the landfill border area.

Air

In order to quantify the air pathway, the following procedures were used for particulates and volatiles.

The concentration in air of a specific chemical of potential concern that is present in respirable particulate matter (PM_{10}, particulate matter less than 10 μm in diameter) in air is calculated from the concentration in soil as follows:

$$C_{(air)}(mg/m^3 \text{ air}) = C_{(soil)}(mg/kg) \times PM_{10} \ (kg/m^3) \qquad (2)$$

Appendix 2 describes the estimation of PM_{10} concentrations for each exposure point evaluated using emission and transport modeling. These values were then used in Equation 2 along with the values of exposure point concentrations in soil to calculate contaminant concentrations in air.

No monitoring data were available to indicate the concentrations of volatiles in air due to release at the site. Therefore, a soil volatilization model and a box model were used to calculate the average concentrations that would be expected, based on the measured levels in soil. The volatilization model chosen was Hwang (1986) as suggested by USEPA (1988a). A detailed description of the Hwang model, box model and all input parameters employed is presented in Appendix 3.

Samples used in calculations of exposure point concentrations are summarized in Table 3-4. Worksheets documenting exposure point concentrations are included in Appendix 4.

3.3.2 Calculation of Human Intake Factors

In the general equation for calculating intake (Equation 1), the HIF incorporates the terms that describe exposure in terms of human activity. The value of the HIF term in calculating chemical intakes depends on the specific exposure scenario being evaluated. An HIF value is calculated individually for each exposed population, for each medium, for each exposure route and for each exposure duration. In general, an HIF value is comprised of three terms:

- A contact rate term that describes the amount of intake of a medium (e.g., mg of soil or L of water) by a person on a day when exposure occurs.

- A body weight term.

- A series of time correction factors that account for the fact that exposure may not occur every day during the time period of interest. These variables include exposure time (hours/day), exposure frequency (days/year) and exposure duration (years). These factors are divided by the period (in days) over which exposure is averaged (averaging time).

Activity Patterns of Potentially Exposed Populations

Human intake factors are derived for all assumed populations (Table 3-3). A brief description of the assumed activity patterns of these populations is presented below.

Hypothetical Future On-Site Residents. A maximally exposed adult resident would be an adult who works at home, is retired or unemployed. A child is maximally exposed during the ages at which contact with contaminated media is greatest and when time at home is greatest. Therefore, a child aged one to six years is evaluated. The resident assumed to live in a home constructed on site (either on the landfill or south of it) and drink from a well drilled near their home.

Current Off-Site Downwind Resident. These individuals represent child and adult residents who are exposed to airborne site contaminants via volatiles and wind and mechanical (dirt-bike riding) erosion. The maximally exposed individuals would be a full-time adult resident and a child resident aged one to six years.

TABLE 3-4 SUMMARY OF MONITORING DATA USED IN CALCULATING EXPOSURE POINT CONCENTRATIONS

Exposure Point	Samples Used[a]
Current Land Use Scenarios:	
Site area utilized for dirt-bike riding; Off-site residence (downwind)	WS-03 to WS-06, WS-10 to WS-12, WS-14, WS-15, GS-01 to GS-12, HS-03 to 07, HS-09
Site surface water bodies and sediment (quarry pit pond)	SS-09 to SS-12, SS-16 to 18 and SD-09 to SD-12, SD-16 to SD-18
Site surface water bodies and sediment (2 smaller ponds)	SS-01 to SS-08, SS-13 to SS-15, SD-01 to SD-08 and SD-13 to SD-15
Hypothetical Future Land Use Scenarios:	
On-site residence or plant south of landfill - soil	WS-13 to 16, HS-06 to HS-09, TL-3DS1
- groundwater	
- shallow well[b]	WTE-2, WTM-2, WT-101A, WT-111A
- deep well	WTE-3, WTM-1, WT-101B, WT-101C
On-site residence/plant/cropland on landfill - soil	WS-03 to WS-06, WS-10 to WS-12, GS-01 to GS-12
- groundwater	TL-1, TL-2, TL-4, WTCP-1, WT-103A
Off-site residence (downwind)	WS-03 to WS-06, WS-10 to WS-12, WS-14, WS-15, GS-01 to GS-12, HS-03 to HS-05

(a) All associated field duplicate samples were averaged prior to the calculation of exposure point concentrations.
(b) Residence only.

Future Off-Site Residents - Downwind. These residents (adult and a one- to six-year-old child) are assumed to be the maximally exposed individuals located downwind (northeast) of the site who inhale volatiles and airborne particulates from wind and mechanical (plowing) erosion from the site assuming it is developed as agricultural land. These populations differ from the current off-site downwind resident only in their additional exposure to dust generated via agricultural activities.

Current Dirt-Bike Rider. This individual represents a young adult who may visit the site for the purposes of dirt-bike riding. For the purposes of evaluating a maximally exposed individual over a lifetime, it is assumed the dirt-bike rider is an adult male over the age of 18 years. It is possible that older children (e.g., ages 12 to 18) would participate in this type of activity. Although this individuals' dose could be slightly higher than an adult (since they weigh less), their exposure duration would also be less (six years). Therefore, an adult represents the maximally exposed individual for this activity.

Current Wader. It is assumed that a younger individual (aged 12 to 18 years) rather than an adult would be more likely to fish, play or wade in the three surface water bodies. It is assumed this older child may go fishing either in the quarry pit pond or the two smaller ponds and play or wade along the edges of these ponds. For the purposes of this assessment, this individual will be referred to as the "wader."

Hypothetical Future On-Site Plant Workers. These individuals are assumed to be adults who could work at a plant or facility constructed in the same section of the site as a hypothetical residence (either on the landfill or just south of it). It is assumed the work is indoors and does not entail significant outdoor labor and that drinking water is available from a well drilled near the building.

Hypothetical Future On-Site Agricultural Workers. These adults are assumed to work on site assuming the site is developed as a field of crops (such as soybeans or corn). It is assumed an agricultural worker works in the field plowing/tilling in the spring and performs related operations occasionally during the growing season (May to September). Exposures to particulates only occurs during those plowing/tilling activities that generate dust. It is also assumed the worker has access to drinking water during his workday from an on-site drinking water well.

Quantitative Evaluations

The following values are used in the pathway-specific exposure calculations unless otherwise specified in the individual exposure scenarios described below.

Body Weight. An average human body weight of 70 kg (154 lb) is assumed for adults (residents, plant and agricultural workers and dirt-bike rider). An average body weight of 15 kg (33 lb) is assumed for children aged one to six years (resident) (USEPA 1991c). An average body weight of 56 kg (123 lb) is assumed for the 12-to 18-year-old wader (USEPA 1989b).

Exposure Frequency. Residential exposure frequency is based on full-time residence, with 15 days per year spent away from home, resulting in a residential exposure frequency of 350 days per year (USEPA 1991c). This frequency is assumed for all residential exposures.

For agricultural workers, exposure is assumed to occur during the spring and occasionally during the growing season (May through September). It is assumed these workers work a total of 20 days/year. Ten of these 20 days are assumed to involve plowing/tilling operations.

Occupational exposure frequency is assumed to be five days per week and to occur year-round except for a two-week vacation, resulting in an exposure of 250 days per year (USEPA 1991c).

Frequency of exposure for recreational populations is uncertain. For the dirt-bike rider, it is assumed a reasonable maximum exposure would be two days a week on site during the non-winter months (e.g., nine months per year) of the year or 39 weeks per year, for a total of 78 days per year. It is suspected that any dirt-bike riding which may occur during the winter months (i.e., during a warm spell) would be balanced by periods during the summer months that riding would be unlikely to occur (i.e., periods of heavy rains, vacations away from home). For the wader, it is assumed a reasonable maximum exposure would be two days per week during the non-school months of the year (approximately three months from mid-June to Labor Day) or 11 weeks per year, for a total of 22 days per year.

Exposure Duration. Residents typically live in a single home for an average of 9 years and up to a reasonable maximum of 30 years (USEPA 1991c). Based on this, exposure duration of adult residents is assumed to be 30 years. Exposure duration for a child resident is assumed to be six years. Workers typically stay at a single job for 25 years or less based on a Bureau of Labor Statistics data (USEPA 1991c), and an exposure duration of 25 years is therefore assumed for the plant worker. No data exist to determine the average length of employment for an agricultural worker, therefore, 25 years is also assumed for the agricultural worker.

The exposure duration for the dirt-bike rider is 30 years, assuming a resident may ride on the site for the period of time he lives near the site. The exposure duration for the wader is six years, the period from 12 to 18 years of age.

Exposure Time. The exposure time for inhalation exposures is 24 hours a day for residents and 8 hours a day for workers (USEPA 1989a). It is further assumed that tilling/plowing are limited to one hour/event. This is the average time to till a field the size of the site. For residential dermal exposures one, ten-minute shower or bath per day is assumed.

There are no available data on exposure times for specific recreational populations, such as dirt-bike riders. Therefore, in the absence of data the exposure time for the dirt-bike rider populations is assumed to be two hours per week or one hour per event. This is supported by estimates of reasonable average maximum exposures (90th percentile of weighted mean hours per week) (USEPA 1989b) for similar outdoor activities. These estimates range from one to three hours per week.

A reasonable maximum exposure time for a wader is also assumed to be two hours per week, or one hour per event, two events per week. This is assumed based on a study that determined an average of 2 hours per week is spent outdoors by male children aged 12 to 17 years of age while school is open (USEPA 1989b). It is assumed that time spent outdoors would double or triple while out of school, and a portion of this time may be spent wading or swimming in the site ponds. Therefore, it is assumed two hours per week is spent on site wading or swimming in the ponds.

Averaging Time. The averaging time is equal to the exposure duration for subchronic and chronic (noncancer) risks and 70 years for lifetime (cancer) risk (USEPA 1991c).

Contact Rate Terms

Ingestion of Soil. Available data on soil and dust ingestion by humans under typical residential conditions indicate that most soil ingestion occurs by hand-to-mouth activity (cigarette smoking, nail biting, finger wetting, etc.) and during meals (Hawley 1985). For children, mouthing of nonfood items is nearly universal during infancy and decreases with age (Sedman 1989).

For residents, the reasonable maximum soil intake is estimated to be 200 mg per day for children (aged one to six years) and 100 mg per day for adults (USEPA 1991c). These factors account for soil intake of both outdoor soil and indoor dust and are assumed to include episodes of possible increased soil ingestion due to engaging in normal outdoor activities. Thus, an intake of soil and dust of 200 mg/day is assumed for child residents and 100 mg/day is assumed for adult residents. The calculation of HIFs for adult residents is based on a time-weighted equation in which a six-year exposure duration is evaluated at the higher soil ingestion rate (200 mg/day) and lower body weight (15 kg) and a 24-year exposure duration at a lower soil ingestion rate (100 mg/day) and the higher adult body weight (70 kg). All of the ingestion soil is assumed come from site surface soil, i.e., the fractional intake of site soil is 1.0.

For workers, soil intake is highly dependent on the type of activity, and quantitative data on soil ingestion are lacking. Hawley (1985) (USEPA 1991c) estimated adult soil intake of 110 mg/day from cleaning dusty areas and of 480 mg/day from doing yard work for eight hours per day. Calabrese et al. (1990) estimated 50 mg/day for adults who worked outside the home. In the absence of quantitative data, it is assumed that the intake for plant workers is 50 mg/day (USEPA 1991c) and that the activities of the agricultural worker are similar to yard work and therefore the intake is assumed to be 480 mg/day.

For the dirt-bike rider, it is assumed that the intake on site would be considerably higher than an average residential intake, however, the fraction of time (one hour per event) spent on site would limit the intake. In the absence of data, it is assumed that a dirt-bike rider would ingest 50 mg/event of site soils while dirt-bike riding.

Ingestion of Sediments. No data exist on the amount of sediment ingested by children or adults during recreational activities. The 200 mg/day or 50 mg/event soil intake by child residents or dirt-bike riders, respectively, would overestimate an ingestion rate for this type of activity. In the absence of any data, an ingestion rate for sediments is assumed to be 10 mg/event.

Dermal Contact with Surface Water. It is assumed the wader is dressed in a short-sleeved shirt and pants without shoes, which is a total of 4,314 cm^2 of surface area available for contact. However, it is further assumed the wader may go into the water to his knees, thereby also exposing lower legs, resulting in 6,873 cm^2 exposed surface areas exposed to water (USEPA 1989b).

Dermal Contact with Groundwater. It is assumed individuals are totally immersed while showering or bathing. Total skin surface area is assumed as 10,000 and 20,000 cm^2 for children and adults, respectively (USEPA 1989b).

Ingestion of Groundwater. Groundwater is assumed to be the source of drinking water. Reasonable maximum values for ingestion of drinking water are 2 L/day for adults and 1 L/day for children (USEPA 1989b, USEPA 1991c). These values are used for all resident populations. For occupational populations a 1 L/day ingestion rate is used (USEPA 1991c).

Inhalation of Volatiles Released from Groundwater. The presence of volatile contaminants in groundwater leads to inhalation exposure of residents due to release of volatiles to indoor air during household uses of water (use of showers, sinks, washing machines, toilets, dishwashers, etc). The amount of human exposure is a complex function of showering and bathing habits, water temperature and flow rate, whole-house water usage, the size and ventilation characteristics of the bathroom, laundry and house, time spent in each room, and the physical-chemical properties of the contaminants themselves (e.g., Henry's Law constant).

A number of researchers have developed mathematical models to predict air concentration values and/or inhalation doses as a function of the concentration of a contaminant in the water (e.g., McKone 1987, Foster and Chrostowski 1987, Small et al. 1990). As expected, the results vary depending upon the assumptions used in the calculations. Most studies indicate that a reasonable maximum for the inhalation dose ranges from about one-half to five times higher than the ingested dose, with most estimates falling between one and three times the ingestion dose (McKone 1987, Foster and Chrostowski 1987, Small et al. 1990). Since site-specific data are not available to support a detailed evaluation of inhalation exposure to volatiles, a representative exposure level of twice the oral dose has been assumed. Thus the inhaled doses for each resident population are two times the corresponding oral intakes.

Inhalation Rate of Volatiles and Contaminated Particulates. The International Commission on Radiologic Protection determined that a daily inhalation rate of 21 to 23 m^3/day represented an average inhalation rate for male and female adults respectively, engaged in 16 hours at a light activity level (i.e., domestic work, personal care and hobbies) and 8 hours at the rest level (i.e., reading, watching television and sleeping) (USEPA 1991e, USEPA 1989b). More recently, USEPA (USEPA 1991c) has reevaluated the reasonable maximum inhalation rate using activity-specific inhalation rates and specific time-use/activity level data. The conclusion was that 20 m^3/day (0.83 m^3/hr) is representative of a reasonable maximum exposure for adult residents who spend the majority of the day at home. An identical value is assumed for plant workers. The daily inhalation rate of children, however, was not evaluated. In the absence of data, it is assumed a child (up to six years of age) would spend 12 hours a day at a resting level, 8 hours a day at a light level and 4 hours at the moderate activity level (based on time use data (USEPA 1989b)). The following weighting calculation was performed:

Activity Level	Hours/Day	Inhalation Rate, m^3/hr	Time-weighted Inhalation Rate, m^3/day
Resting	12	0.4	4.8
Light	8	0.8	6.4
Moderate	4	2.0	8.0
Heavy	0	2.4	0.0
Total	24	Rate/day:	19.2

Therefore, it is assumed the daily inhalation rate for a child resident is also 20 m^3/day or 0.83 m^3/hr.

The inhalation rate of agricultural workers was calculated in a similar manner. It is assumed agricultural workers are exposed to chemicals volatilizing from soils for a eight-hour work day. Therefore, inhalation of volatiles is based on an assumed estimate that five hours are spent at a moderate activity level (i.e., bending, digging, weeding and mulching), and the rest of the workday is divided between light and heavy (digging, hoeing) activities. The following exhibits the calculation performed:

Activity Level	Hours/Day	Inhalation Rate, m^3/hr	Time-weighted Inhalation Rate, m^3/day
Light	1.5	0.6	0.9
Moderate	5	2.1	10.5
Heavy	1.5	3.9	5.9
Total	8	Rate/workday:	17.3
		Rate/hr:	2.2

Therefore, an inhalation rate of 2.2 m^3/hr, is used for agricultural workers.

It is assumed dirt-bike riding is a moderately heavy activity, and a value of 2.5 m^3/hour is used as the inhalation rate for the dirt-bike rider (USEPA 1989b).

Ingestion of Surface Water. An estimated water ingestion rate while swimming is 0.05 liter per hour (USEPA 1989a). It is assumed that wading activities involve considerably less surface water ingestion. A value of 0.025 liter per event (or one-half a swimming ingestion rate) is assumed in the absence of any other data.

Permeability Constant. An additional parameter needed to calculate dermal intake from water is the permeability constant (PC), in cm/hr (USEPA 1989a). This is a chemical-specific value based on toxicological parameters. The specific PC values used are discussed in detail in Section 4.3.

Summary

Tables 3-5 through 3-11 present calculations of individual HIF values. The resulting HIF values are summarized in Table 3-12.

3.3.3 Calculation of Average Daily Intakes

Average daily intakes (subchronic, chronic and lifetime) were calculated using the exposure point concentrations derived as described in Section 3.3.1 and HIF terms derived as described in Section 3.3.2. These calculations are summarized in Appendix 5.

TABLE 3-5 HIF CALCULATIONS FOR INCIDENTAL INGESTION OF SOIL

$$\text{Basic HIF Equation:}^{(a)}\ (\text{kg/kg-day}) = \frac{IR_1 \times CF \times FI \times EF \times ED_1}{BW_1 \times AT_1}$$

$$\text{Time-Weighted HIF Equation}^{(b)}\ (\text{kg/kg-day}) = \frac{(IR_1 \times EF \times ED_1/BW_1) + (IR_2 \times EF \times ED_2/BW_2) \times FI \times CF}{AT}$$

		Population - Specific Values									
				Future Site Resident				Future			
		Dirt-Bike Rider		Child		Adult		Plant Worker		Agricultural Worker	
Symbol[c]	Units	Chronic	Lifetime	Subchronic	Lifetime	Chronic	Lifetime	Chronic	Lifetime	Chronic	Lifetime
IR_1	mg/day	50	50	200	200	200	200	50	50	480	480
IR_2	mg/day	NA[d]	NA	NA	NA	100	100	NA	NA	NA	NA
CF	kg/mg	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
FI	unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
EF	days/yr	78	78	350	350	350	350	250	250	20	20
ED_1	yr	30	30	6	6	6	6	25	25	25	25
ED_2	yr	NA	NA	NA	NA	24	24	NA	NA	NA	NA
BW_1	kg	70	70	15	15	15	15	70	70	70	70
BW_2	kg	NA	NA	NA	NA	70	70	NA	NA	NA	NA
AT	yr (days)	30(10,950)	70(25,550)	6(2,190)	70(25,550)	30(10,950)	70(25,550)	25(9,125)	70(25,550)	25(9,125)	70(25,550)
HIF	(kg/kg-day)	1.5E-07	6.5E-08	1.3E-05	1.1E-06	3.7E-06	1.6E-06	4.9E-07	1.7E-07	3.8E-07	1.3E-07

(a) Equation for the dirt-bike rider, future child resident, future plant worker and future agricultural worker.
(b) Equation for the future adult resident.
(c) IR = Ingestion Rate, CF = Conversion Factor, FI = Fractional Intake, EF = Exposure Frequency, ED = Exposure Duration, BW = Body Weight, AT = Averaging Time, HIF = Human Intake Factor.
(d) NA = Not Applicable for this exposure scenario.

TABLE 3-6 HIF CALCULATIONS FOR INGESTION OF POND SEDIMENTS - WADER

Basic Equation: $$\text{HIF (kg/kg-day)} = \frac{\text{IR} \times \text{CF} \times \text{FI} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Symbol	Variable	Units	Wader	
			Subchronic	Lifetime
IR	Ingestion Rate	mg/day	10	10
CF	Conversion Factor	kg/mg	1E-06	1E-06
FI	Fractional Intake	unitless	1.0	1.0
EF	Exposure Frequency	events/yr	22	22
ED	Exposure Duration	yr	6	6
BW	Body Weight	kg	56	56
AT	Averaging Time	yr (days)	6(2,190)	70(25,550)
HIF	Human Intake Factor	kg/kg-day	1.1E-08	9.2E-10

TABLE 3-7 HIF CALCULATIONS FOR DERMAL CONTACT WITH SURFACE WATER - WADER

Basic Equation: $$\text{HIF (L/kg-day)} = \frac{SA \times PC \times CF \times ET \times EF \times ED}{BW \times AT}$$

Symbol	Variable	Units	Wader Subchronic	Wader Lifetime
SA	Surface Area	cm^2	6,873	6,873
CF	Conversion Factor	L/cm^3	1E-03	1E-03
ET	Exposure time	hr/events	1	1
EF	Exposure Frequency	events/yr	22	22
ED	Exposure Duration	yr	6	6
BW	Body Weight	kg	56	56
AT	Averaging Time	yr(days)	6(2,190)	70(25,550)
HIF	Human Intake Factor[a]	(L/kg-day)	7.4E-03	6.3E-04

(a) HIF value must be multipled by the chemical-specific permeability constant (PC) term (cm/hr).

TABLE 3-8 HIF CALCULATIONS FOR INGESTION OF DRINKING WATER

Basic Equation: $$\text{HIF (L/kg-day)} = \frac{IR \times EF \times ED}{BW \times AT}$$

Symbol	Variable	Units	Population - Specific Values: Current and Future Residents — Child — Subchronic	Child — Lifetime	Adult — Chronic	Adult — Lifetime	Future — Plant Worker — Chronic	Plant Worker — Lifetime	Agricultural Worker — Chronic	Agricultural Worker — Lifetime
IR	Ingestion Rate	L/day	1	1	2	2	1	1	1	1
EF	Exposure Frequency	day/yr	350	350	350	350	250	250	20	20
ED	Exposure Duration	yr	6	6	30	30	25	25	25	25
BW	Body Weight	kg	15	15	70	70	70	70	70	70
AT	Averaging Time	yr (days)	6(2,190)	70(25,550)	30(10,950)	70(25,550)	25(9,125)	70(25,550)	25(9,125)	70(25,550)
HIF	Human Intake Factor	L/kg-day	6.4E-02	5.5E-03	2.7E-02	1.1E-02	9.8E-03	3.5E-03	7.8E-04	2.8E-04

TABLE 3-9 HIF CALCULATIONS FOR INHALATION OF VOLATILES AND PARTICULATES

Basic Equation: $$HIF\ (m^3/kg\text{-}day) = \frac{IR \times ET \times EF \times ED}{BW \times AT}$$

		Population - Specific Values											
				Residents				Agricultural Worker (Volatiles)		Agricultural Worker (Particulates)		Plant Worker	
		Dirt-Bike Rider		Child		Adult							
Symbol[a]	Units	Chronic	Lifetime	Subchronic	Lifetime	Chronic	Lifetime	Chronic	Lifetime	Chronic	Lifetime	Chronic	Lifetime
IR	m^3/hr or m^3/event	2.5	2.5	0.83	0.83	0.83	0.83	2.2	2.2	2.1	2.1	0.83	0.83
ET	hr/event or hr/day	1	1	24	24	24	24	8	8	1	1	8	8
EF	days/yr	78	78	350	350	350	350	20	20	10	10	250	250
ED	yr	30	30	6	6	30	30	25	25	25	25	25	25
BW	kg	70	70	15	15	70	70	70	70	70	70	70	70
AT	yr (days)	30 (10,950)	70 (25,550)	6 (2,190)	70 (25,550)	30 (10,950)	70 (25,550)	25 (9,125)	70 (25,550)	25 (9,125)	70 (25,550)	25 (9,125)	70 (25,550)
HIF	m^3/kg-day	7.6E-03	3.3E-03	1.3E+00	1.1E-01	2.7E-01	1.2E-01	1.4E-02	4.9E-03	8.2E-04	2.9E-04	6.5E-02	2.3E-02

(a) IR = Ingestion Rate, ET = Exposure Time, EF = Exposure Frequency, ED = Exposure Duration, BW = Body Weight, AT = Averaging Time, HIF = Human Intake Factor.

TABLE 3-10 HIF CALCULATIONS FOR INGESTION OF SURFACE WATER - WADER

Basic Equation: $HIF\ (L/kg\text{-}day) = \frac{IR \times EF \times ED}{BW \times AT}$

Symbol	Variable	Units	Wader Subchronic	Wader Lifetime
IR	Ingestion Rate	L/event	0.025	0.025
EF	Exposure Frequency	event/yr	22	22
ED	Exposure Duration	yr	6	6
BW	Body Weight	kg	56	56
AT	Averaging Time	yr (days)	6(2,190)	70(25,550)
HIF	Human Intake Factor	L/kg-day	2.7E-05	2.3E-06

TABLE 3-11 HIF CALCULATIONS FOR DERMAL EXPOSURES TO GROUNDWATER DURING HOUSEHOLD USES

Basic Equation: $$\text{HIF (L/kg-day)} = \frac{SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

			Current and Future Residents			
			Child		Adult	
Symbol	Variable	Units	Subchronic	Lifetime	Chronic	Lifetime
SA	Surface area	cm^2	10,000	10,000	10,000	10,000
ET	Exposure time	hr/day	0.17[a]	0.17	0.17	0.17
EF	Exposure frequency	days/yr	350	350	350	350
ED	Exposure duration	yr	6	6	30	30
CF	Conversion factor	L/cm^3	1E-03	1E-03	1E-03	1E-03
BW	Body weight	kg	15	15	70	70
AT	Averaging time	yr(days)	6(2,190)	70(25,550)	30(10,950)	70(25,550)
HIF	Human Intake Factor[b]	(L/kg-day)	1.1E-01	9.3E-03	2.3E-02	1.0E-02

(a) Equals 10 min/day.
(b) HIF value must be multiplied by the chemical-specific permeability constant (PC) term (cm/hr).

TABLE 3-12 SUMMARY OF HIF CALCULATIONS

Land Use	Exposed Population	Exposure Point	Exposure Medium	Exposure Route	HIF_S	HIF_C	HIF_L
Current	Downwind off-site resident						
	Adult	Home	Air	Inhalation	--[a]	2.7E-01	1.2E-01
	Child	Home	Air	Inhalation	1.3E+00	--	1.1E-01
Current	Dirt-bike rider	Site	Soil	Ingestion	--	1.5E-07	6.5E-08
			Air	Inhalation	--	7.6E-03	3.3E-03
Current	Wader	Site ponds & Quarry Pit	Surface water	Ingestion	2.7E-05	--	2.3E-06
				Dermal	7.4E-03	--	6.3E-04
			Sediments	Ingestion	1.1E-08	--	9.2E-10
Future	Site resident						
	Adult	Home	Groundwater	Ingestion	--	2.7E-02	1.1E-02
				Inhalation-Volatiles[b]	--	5.4E-02	2.2E-02
				Dermal	--	2.3E-02	1.0E-02
			Soil	Ingestion	--	3.7E-06	1.6E-06
			Air	Inhalation	--	2.7E-01	1.2E-01
	Child	Home	Groundwater	Ingestion	6.4E-02	--	5.5E-03
				Inhalation-Volatiles[b]	1.3E-01	--	1.1E-02
				Dermal	1.1E-01	--	9.3E-03
			Soil	Ingestion	1.3E-05	--	1.1E-06
				Dermal	1.1E-04	--	9.4E-06
			Air	Inhalation	1.3E+00	--	--
Future	Plant Worker	Plant	Groundwater	Ingestion	--	9.8E-03	3.5E-03
			Soil	Ingestion	--	4.9E-07	1.7E-07
			Air	Inhalation	--	6.5E-02	2.3E-02
Future	Agricultural Worker	Site	Groundwater	Ingestion	--	7.8E-04	2.8E-04
			Soil	Ingestion	--	3.8E-07	1.3E-07
			Air	Inhalation-Particulates	--	1.4E-02	4.9E-03
				-Volatiles	--	8.2E-04	2.9E-04
Future	Downwind off-site resident						
	Adult	Home	Air	Inhalation	--	2.7E-01	1.2E-01
	Child	Home	Air	Inhalation	1.3E+00	--	1.1E-01

(a) "--" = Not Evaluated.
(b) Inhalation intake calculated as twice oral intake (ingestion) for volatiles in groundwater.

4.0 TOXICITY ASSESSMENT

The purpose of this section of the risk assessment is to summarize the available evidence regarding the nature and extent of adverse health effects that the chemicals of potential concern could produce in an exposed individual. The toxic effects of a chemical depend not only upon its inherent toxicity and the level of exposure (dose), but also upon the route of exposure (oral, inhalation, dermal) and the duration of exposure (subchronic, chronic or lifetime). Thus, a complete description of the toxic effects of a chemical includes a list of the effects the chemical may cause and an analysis of how these effects depend on dose, route and exposure duration. When data permit, the USEPA derives numeric values useful in quantifying the noncarcinogenic and carcinogenic effects of chemicals. These values are described in the following sections.

4.1 Noncarcinogenic Effects

For noncarcinogenic health effects, the toxicity values are termed reference doses (RfDs). These values are both route specific (oral and inhalation) and duration specific (chronic and subchronic). The RfD is an estimate of the average daily intake that may occur without appreciable risk of any adverse effect. The RfD is usually calculated from experimental data, which identify a No-Observed-Adverse-Effect Level (NOAEL) or a Lowest-Observed-Adverse-Effect Level (LOAEL) in animals or humans. Because the experimental data vary in quality and quantity among chemicals, USEPA also provides an indication of the level of confidence associated with the RfD value. In general, the lower the confidence, the more conservative USEPA is in deriving the RfD. Table 4-1 summarizes the noncancer effects of the chemicals of potential concern identified at this site. The table also contains available RfD values and the confidence categories for all verified RfDs.

4.2 Carcinogenic Effects

For cancer the numeric descriptors of carcinogenic potency are termed Slope Factors (SFs). These are route-specific estimates of the slope of the dose-response curve at low doses. It is assumed the curve is linear in this region and passes through the origin. The units of the SF are $(mg/kg\text{-}day)^{-1}$. To ensure an adequate margin of safety, the SF is taken to be the upper 95th percent confidence limit of the slope. Thus, the actual slope factors could be lower but are not likely to be higher. Table 4-2 summarizes the slope factors available for chemicals of potential concern identified at the Himco Dump site.

TABLE 4-1 SUMMARY OF NONCARCINOGENIC EFFECTS AND CRITICAL TOXICITY VALUES FOR CHEMICALS OF POTENTIAL CONCERN AT THE HIMCO DUMP SITE[a]

Chemical	Effect - Route	Oral CTV			Inhalation CTV		
		RfD_S[b]	RfD_C[b]	Confidence Level	RfD_S[b]	RfD_C[b]	Confidence Level
Acenaphthene	Liver effects-oral	6.0E-01	6.0E-02	Low	--	--	--
Acenaphthylene	(c)	(c)	(c)	--	--	--	--
Acetone	Increased liver and kidney weights, nephrotoxicity-oral	1.0E+00	1.0E-01	Low	--	--	--
Aluminum	Asthma, pulmonary fibrosis-inhalation; neurological disorders following ingestion of large doses or kidney dialysis (ATSDR 1990a)	--	--	--	--	--	--
Aldrin	Liver toxicity-oral	3.0E-05	3.0E-05	Medium	--	--	--
alpha-BHC	--	--	--	--	--	--	--
alpha-Chlordane	Liver necrosis-oral	6.0E-05	6.0E-05	Low	--	--	--
Anthracene	No treatment related effects observed	3.0E+00	3.0E-01	Low	--	--	--
Antimony	Decreased longevity, changes in blood glucose, cholesterol-ingestion	4.0E-04	4.0E-04	Low	--	--	--
Aroclor-1248	Liver effects, chloracne-all routes (ATSDR 1989e)	--	--	--	--	--	--
Arsenic	Mucous membrane irritation-inhalation; liver and kidney effects-oral; keratosis, hyperpigmentation, neurological disorders-both routes (ATSDR 1989a)	3.0E-04	3.0E-04	Medium	--	--	--
Barium	Hypertension-oral	7.0E-02	7.0E-02	Medium	1.0E-03	1.0E-04	--
Benzene	--	--	--	--	--	--	--
Benzo(a)anthracene	(d)	--[d]	--[d]	--	--	--	--
Benzo(a)pyrene	(d)	--[d]	--[d]	--	--	--	--

continued-

(a) All information from either IRIS Database (USEPA 1992b) or HEAST Tables (USEPA 1991c) unless otherwise noted.
(b) Units of the RfD are mg/kg-day.
(c) Noncarcinogenic effects of this PAH evaluated using the RfD for acenaphthene. See Appendix 6 for details.
(d) Noncarcinogenic effects of this PAH evaluated using the RfD for pyrene. See Appendix 6 for details.

Table 4-1 - continued

Chemical	Effect - Route	Oral CTV RfD$_S$	Oral CTV RfD$_C$	Oral CTV Confidence Level	Inhalation CTV RfD$_S$	Inhalation CTV RfD$_C$	Inhalation CTV Confidence Level
Benzo(b)fluoranthene	(a)	--[(a)]	--[(a)]	--	--	--	--
Benzo(g,h,i)perylene	(a)	--[(a)]	--[(a)]	--	--	--	--
Benzo(k)fluoranthene	(a)	--[(a)]	--[(a)]	--	--	--	--
Benzoic acid	Irritation, malaise-oral	4.0E+00	4.0E+00	--	--	--	--
Benzyl alcohol	Hyperplasia of forestomach epithelium, decrease in body weight-oral	1.0E+00	3.0E-01	--	--	--	--
Beryllium	No adverse effects noted	5.0E-03	5.0E-03	Low	--	--	--
beta-BHC	--	--	--	--	--	--	--
Bromodichloromethane	Kidney, liver and thyroid gland toxicity	2.0E-02	2.0E-02	Medium	--	--	--
bis(2-ethylhexyl)phthalate	Liver toxicity, reproductive and developmental effects-ingestion (ATSDR 1989d)	2.0E-02	2.0E-02	Medium	--	--	--
2-Butanone	Central nervous system effects, fetotoxicity-inhalation	5.0E-01	5.0E-02	Medium	9.0E-01	9.0E-02	--
Butylbenzylphthalate	Liver and kidney changes, hematological and reproductive effects	2.0E+00	2.0E-01	Low	--	--	--
Cadmium (food) (water)	Renal damage-both routes; impaired respiratory function-inhalation; possible immune alterations-ingestion (ATSDR 1989b)	-- --	1.0E-03 5.0E-04	High High	-- --	-- --	-- --
Carbon disulfide	Neurological, cardiovascular, developmental and hepatic effects following inhalation (ATSDR 1990b)	1.0E-01	1.0E-01	Medium	2.9E-03	2.9E-03	--
Carbazole	--	--	--	--	--	--	--
Chloride	--	--	--	--	--	--	--
Chlorobenzene	Liver damage after ingestion	2.0E-01	2.0E-02	Medium	5.0E-02	5.0E-03	--
Chloroethane	Neurological effects - inhalation	--	--	--	--	--	--

continued-

(a) Noncarcinogenic effects of this PAH evaluated using the RfD for pyrene. See Appendix 6 for details.

Table 4-1 - continued

Chemical	Effect - Route	Oral CTV			Inhalation CTV		
		RfD_S	RfD_C	Confidence Level	RfD_S	RfD_C	Confidence Level
Chloroform	Liver and kidney toxicity following inhalation and ingestion; central nervous system depression following inhalation (ATSDR 1989c)	1.0E-02	1.0E-02	Medium	--	--	--
Chromium (VI)[a]	Atrophy of nasal mucosa-inhalation; no effects defined after oral exposure	2.0E-02	5.0E-03	Low	5.7E-06	5.7E-07	--
Chrysene	(b)	--[b]	--[b]	--	--	--	--
Cobalt	Asthma, fibrosis-inhalation. Cardio-myopathy-ingestion (ATSDR 1990d)	--	--	--	--	--	--
Cyanide (free)	Weight loss, thyroid effects, myelin degeneration-oral	2.0E-02	2.0E-02	Medium	--	--	--
4,4-DDE	--	--	--	--	--	--	--
4,4'-DDT	Liver damage-oral	5.0E-04	5.0E-04	Medium	--	--	--
Di-n-butylphthalate	Increased mortality-ingestion	1.0E+00	1.0E-01	Low	--	--	--
Di-n-octylphthalate	Kidney and liver damage-oral	2.0E-02	2.0E-02	--	--	--	--
Dibenz(a,h)anthracene	(b)	--[b]	--[b]	--	--	--	--
Dibenzofuran	--	--	--	--	--	--	--
1,1-Dichloroethane	Renal damage-inhalation; no effect-oral	1.0E+00	1.0E-01	--	1.0E+00	1.0E-01	--
1,1-Dichloroethene	Hepatic lesions and fetal toxicity	9.0E-03	9.0E-03	Medium	--	--	--
1,2-Dichloroethene (total)[c]	Hematologic changes	1.0E-01	1.0E-02	--	--	--	--
1,4-Dichlorobenzene	Liver and kidney effects-inhalation	--	--	--	2.0E-01	2.0E-01	--
Dieldrin	Liver lesions-oral	5.0E-05	5.0E-05	Medium	--	--	--
Diethylphthalate	Reduced growth rate, altered organ weights	8.0E+00	8.0E-01	Low	--	--	--

continued-

(a) All detected chromium assumed to be hexavalent.
(b) Noncarcinogenic effects of this PAH evaluated using the RfD for pyrene. See Appendix 6 for details.
(c) Based on values for cis-1,2-dichloroethene.

Table 4-1 - continued

Chemical	Effect - Route	Oral CTV RfD$_S$	Oral CTV RfD$_C$	Oral CTV Confidence Level	Inhalation CTV RfD$_S$	Inhalation CTV RfD$_C$	Inhalation CTV Confidence Level
2,4-Dimethylphenol	Clinical signs of toxicity, changes in hematologic parameters-oral	2.0E-01	2.0E-02	Low	--	--	--
Dimethylphthalate	Slight growth rate reduction and kidney effects	1.0E+00	1.0E+00	--	--	--	--
Endosulfan II	Mild kidney lesions-oral	2.0E-04	5.0E-05	Medium	--	--	--
Ethylbenzene	Liver and kidney effects-oral; developmental toxicity-inhalation	1.0E+00	1.0E-01	Low	2.9E-01	2.9E-01	Low
Fluoranthene	Liver and kidney effects-oral	4.0E-01	4.0E-02	Low	--	--	--
Fluorene	Decreased red blood cells, hemoglobin-oral	4.0E-01	4.0E-02	Low	--	--	--
2-Hexanone	--	--	--	--	--	--	--
gamma-Chlordane	Liver necrosis-oral	6.0E-05	6.0E-05	Low	--	--	--
Heptachlor	Increased liver weight-oral	5.0E-04	5.0E-04	--	--	--	--
Indeno(1,2,3-cd)pyrene	(a)	--[a]	--[a]	--	--	--	--
Iron	--	--	--	--	--	--	--
Lead	Neurological deficiencies, hypertension, inhibition heme synthesis, reproductive effects-both routes (ATSDR 1988a)	--[b]	--[b]	--	--[b]	--[b]	--
Mercury	Neurotoxicity-inhalation; kidney effects-oral	3.0E-04	3.0E-04	--	8.6E-05	8.6E-05	--
Methylene chloride	Liver toxicity-ingestion	6.0E-02	6.0E-02	Medium	8.6E-01	8.6E-01	--
2-Methylnaphthalene	(c)	(c)	(c)	--	--	--	--
4-Methyl-2-pentanone	Liver and kidney effects-oral and inhalation	5.0E-01	5.0E-02	--	2.0E-01	2.0E-02	--
2-Methylphenol	Decreased body weight and neurotoxicity-oral	5.0E-01	5.0E-02	Medium	--	--	--

continued-

(a) Noncarcinogenic effects of this PAH evaluated using the RfD for pyrene. See Appendix 6 for details.
(b) Lead will be evaluated based on acceptable blood lead levels using the UBK model.
(c) Noncarcinogenic effects of this PAH evaluated using the RfD for naphthalene. See Appendix 6 for details.

Table 4-1 - continued

Chemical	Effect - Route	Oral CTV RfD_S	Oral CTV RfD_C	Oral CTV Confidence Level	Inhalation CTV RfD_S	Inhalation CTV RfD_C	Inhalation CTV Confidence Level
4-Methylphenol	Decreased body weight and neurotoxicity-oral	5.0E-01	5.0E-02	Medium	--	--	--
Naphthalene	Hemolytic anemia-oral and inhalation; hepatic, reproductive and other effects-oral	4.0E-02	4.0E-03	--	--	--	--
Nickel (soluble salts)	Hematological, developmental effects-ingestion, respiratory, immune and reproductive effects-inhalation (ATSDR 1988b)	2.0E-02	2.0E-02	Medium	--	--	--
Nitrogen, ammonia	Upper respiratory irritant-inhalation. Burns in throat, stomach after ingestion of large amounts (ATSDR 1989g)	--	--	--	--	--	--
Nitrogen, nitrate & nitrite	Methemoglobinemia - ingestion of nitrite	1.0E-01	1.0E-01	High	--	--	--
Phenanthrene	(a)	--[(a)]	--[(a)]	--	--	--	--
Phenol	Developmental and kidney effects-oral	6.0E-01	6.0E-01	Low	--	--	--
Pyrene	Kidney damage-oral	3.0E-01	3.0E-02	Low	--	--	--
Silver	Argyria-oral	5.0E-03	5.0E-03	Low	--	--	--
Sulfate	Diarrhea at high concentrations-ingestion (USEPA 1990d)	--	--	--	--	--	--
Styrene	Liver and red blood cell effects-oral	2.0E+00	2.0E-01	Medium	--	--	--
Tetrachloroethene	Liver and kidney effects following inhalation and ingestion; central nervous system depression following inhalation (ATSDR 1990c)	1.0E-01	1.0E-02	Medium	--	--	--
Thallium	Alopecia and increased liver enzymes-ingestion	7.0E-04	7.0E-05	--	--	--	--
Toluene	Changes in liver and kidney weights-oral; central nervous system effects-inhalation	2.0E+00	2.0E-01	Medium	5.7E-01	5.7E-01	--

(a) Noncarcinogenic effects of this PAH evaluated using the RfD for pyrene. See Appendix 6 for details.

Table 4-1 - continued

Chemical	Effect - Route	Oral CTV			Inhalation CTV		
		RfD_S	RfD_C	Confidence Level	RfD_S	RfD_C	Confidence Level
1,1,1-Trichloroethane	Growth retardation, liver changes-inhalation	9.0E-01	9.0E-02[(a)]	Medium[(a)]	3.0E+00	3.0E-01	--
Trichloroethene	Liver, kidney effects-inhalation and ingestion; central nervous system depression-inhalation (ATSDR 1989f)	--	--	--	--	--	--
Vanadium	Renal and gastrointestinal effects-oral; respiratory irritation-inhalation	7.0E-03	7.0E-03	--	--	--	--
Vinyl chloride	--	--	--	--	--	--	--
Xylenes (total)	Central nervous system toxicity-oral and inhalation; developmental effects-oral	4.0E+00	2.0E+00	Medium	8.6E-02	8.6E-02	--

(a) Removed from IRIS under review.

TABLE 4-2 SUMMARY OF CARCINOGENIC EFFECTS AND SLOPE FACTORS FOR CHEMICALS OF POTENTIAL CONCERN AT THE HIMCO DUMP SITE[a]

Chemical	Target - Route	Weight of Evidence	Slope Factor, $(mg/kg\text{-}day)^{-1}$	
			Oral	Inhalation
Aldrin	Liver-oral	B2	1.7E+01	1.7E+01
alpha-Chlordane	Liver-oral	B2	1.3E+00	1.3E+00
Polychlorinated Biphenyl (Aroclor-1248)[b]	Liver-oral; inadequate but suggestive evidence of liver cancer by inhalation and dermal routes	B2	7.7E+00[b]	--
Arsenic	Lung-inhalation; skin cancer-ingestion; limited evidence of other internal cancers by both routes	A	1.8E+00	1.5E+01
Benzene	Nonlymphocytic leukemia-inhalation and oral	A	2.9E-02	2.9E-02
beta-BHC	Liver-oral	C	1.8E+00	1.8E+00
Benzo(a)pyrene	Stomach-ingestion; respiratory tract-inhalation; skin-dermal[c]	B2	1.2E+01	6.1E+00
Beryllium	Lung cancer-inhalation. Osteo-sarcomas-injection (intravenous or intramedullary)	B2	4.3E+00	8.4E+00

continued-

(a) Information from IRIS Database (USEPA 1992b) or HEAST Tables (USEPA 1991c) unless otherwise noted. Only chemicals with slope factors calculated by EPA are included here.
(b) Evaluated by using the slope factor developed for Aroclor-1260.
(c) Other carcinogenic PAHs evaluated using the benzo(a)pyrene slope factor are:

Benzo(a)anthracene	Chrysene
Benzo(b)fluoranthene	Dibenz(a,h)anthracene
Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene

Table 4-2 - continued

Chemical	Target - Route	Weight of Evidence	Slope Factor, $(mg/kg\text{-}day)^{-1}$ Oral	Inhalation
bis(2-ethylhexyl)phthalate	Liver-ingestion	B2	1.4E-02	--
Bromodichloromethane	Kidney, large intestine and liver tumors by the oral route	B2	1.3E-01	--
Cadmium	Lung, prostate-inhalation; insufficient evidence of carcinogenicity by oral	B1 (inhalation)	--	6.3E+00
Chloroform	Kidney and liver-inhalation and ingestion	B2	6.1E-03	8.1E-02
Chromium (VI)	Lung-inhalation	A (inhalation)	--	4.2E+01
4,4'-DDE	Liver-oral	B2	3.4E-01	--
4,4'-DDT	Liver tumors-oral	B2	3.4E-01	3.4E-01
1,4-Dichlorobenzene	Liver tumors-oral	C	2.4E-02	--
1,1-Dichloroethene	Adrenal-oral, kidney-inhalation	C	6.0E-01	1.8E-01
Dieldrin	Liver, lung-oral	B2	1.6E+01	1.6E+01
gamma-Chlordane	Liver-oral	B2	1.3E+00	1.3E+00
Heptachlor	Liver-oral	B2	4.5E+00	4.6E+00
Lead	Renal tumors-oral (ATSDR 1988a)	B2	--	--
Methylene chloride	Liver-oral and inhalation	B2	7.5E-03	1.6E-03
Styrene	Leukemia-inhalation; lung and bronchi-oral	B2	3.0E-02	2.0E-03

Table 4-2 - continued

Chemical	Target - Route	Weight of Evidence	Slope Factor, $(mg/kg\text{-}day)^{-1}$ Oral	Inhalation
Tetrachloroethene	Liver-inhalation and ingestion; leukemia-inhalation	B2	5.1E-02	1.8E-03
Trichloroethene	Liver-ingestion; lung cancer-inhalation	B2	1.1E-02	6.0E-03
Vinyl chloride	Lung-oral; liver-inhalation	A	1.9E+00	2.9E-01

The USEPA also assigns weight-of-evidence classification to reflect the overall confidence that the chemical is likely to cause cancer in humans. These categories and their meanings are summarized as follows:

Group A	Known human carcinogen
Group B1 or B2	Probable human carcinogen (B1 indicates the availability of limited human data; B2 indicates sufficient evidence in animals but inadequate or no evidence in humans)
Group C	Possible human carcinogen
Group D	Not classifiable as to human carcinogenicity
Group E	Evidence of noncarcinogenicity for humans

4.3 Dermal Toxicity Values

Since dermal exposures to surface water and groundwater are also of concern at the site, dermal toxicity values are also required. It is important to note that dermal toxicity values must be based on the absorbed dose (rather than the exposed or administered dose), since dermal intakes are calculated as absorbed doses. Since the USEPA has not yet established any dermal toxicity values, approximate values were derived by extrapolation from oral toxicity values. This was done by multiplying the oral subchronic or chronic RfD values by the oral absorption fraction (AF_o), and dividing the oral slope factor by the oral absorption fraction. Absorption fractions are chemical-specific values obtained from toxicokinetic studies including, if available, the studies used in determining oral toxicity values. This approach is based on the assumption that equal absorbed doses are equitoxic. For all the organic chemicals of potential concern at the site, the AF_o was assumed to be 1.0 (i.e., 100% oral absorption). Most organic compounds are fairly well absorbed from the gastrointestinal tract. This is, however, not the most conservative approach since a lower AF_o would result in a lower RfD or higher slope factor. Risk may, therefore, be underestimated. No extrapolation from oral to dermal was performed for any PAHs, since these chemicals act at the point of contact (skin, stomach, lungs) and inter-route extrapolation is inappropriate. Oral absorption of metals is quite variable, with values ranging from 0.1% to 60%, while absorption of arsenic is estimated to be 100% (Owen 1990, Seiler and Bigel 1988, Friberg et al. 1986). Therefore, individual AF_o values for inorganic chemicals of potential concern were used to calculate dermal toxicity values. Dermal toxicity values are summarized in Table 4-3.

In evaluating dermal exposures in water another toxicological parameter, the Permeability Constant (PC), is required. Permeability constants reflect the movement of a chemical across the skin into the bloodstream. Permeability constants have been determined experimentally for a limited number of chemicals. Those available are summarized on Table 4-3. Permeability constants can also be estimated based on the molecular weight and log K_{ow} of each chemical. Calculated PC values are also summarized on Table 4-3.

TABLE 4-3 CALCULATION OF DERMAL TOXICITY VALUES AND TOXICOKINETIC FACTORS

Chemical	Oral			Dermal[a]			Toxicokinetic Factors	
	RfD_S	RfD_C	SF	RfD_S	RfD_C	SF	AF_o	PC[b]
INORGANICS:								
Antimony	4.0E-04	4.0E-04	--	2.0E-05	3.0E-04	--	0.05[c]	1.0E-03[d]
Arsenic	3.0E-04	3.0E-04	1.8E+00	3.0E-04	3.0E-04	1.8E+00	1	1.0E-03
Barium	4.0E-02	4.0E-02	--	4.0E-03	5.0E-03	--	0.10	1.0E-03
Beryllium	5.0E-03	5.0E-03	4.3E+00	5.0E-06	5.0E-06	4.3E+03	0.001	1.0E-03
Cadmium (food)	--	1.0E-03	--	--	6.0E-05	--	0.06	1.0E-03
Cadmium (water)	--	5.0E-04	--	--	6.0E-05	--	0.03	1.0E-03
Chromium	2.0E-02	5.0E-03	--	1.0E-03	2.5E-04	--	0.05	1.0E-03
Manganese	1.0E-01	1.0E-01	--	3.0E-03	3.0E-03	--	0.03	1.0E-03
Mercury	3.0E-04	3.0E-04	--	7.5E-05	4.5E-05	--	0.15	1.0E-03
Nickel	2.0E-02	2.0E-02	--	1.0E-03	1.0E-03	--	0.05	1.0E-03
Selenium	--	5.0E-03	--	--	3.0E-03	--	0.60	1.0E-03
Silver	5.0E-03	5.0E-03	--	2.5E-04	2.5E-04	--	0.05	1.0E-03
Thallium	7.0E-04	7.0E-05	--	3.5E-05	2.5E-06	--	0.05	1.0E-03
Vanadium	7.0E-03	7.0E-03	--	1.4E-04	1.4E-04	--	0.02	1.0E-03
Zinc	2.0E-01	2.0E-01	--	1.0E-01	1.0E-01	--	0.50	1.0E-03
Cyanide	2.0E-02	2.0E-02	--	2.0E-02	2.0E-02	--	1.0	1.0E-03
ORGANICS:								
VOLATILES								
1,1-Dichloroethane	1.0E+00	1.0E-01	--	1.0E+00	1.0E-01	--	1	8.9E-03
1,1-Dichloroethene	9.0E-03	9.0E-03	6.0E-01	9.0E-03	9.0E-03	6.0E-01	1	1.6E-02
1,1,1-Trichloroethane	9.0E-01	9.0E-02	--	9.0E-01	9.0E-02	--	1	1.7E-02
1,2-Dichloroethene (total)	1.0E-01	1.0E-02	--	1.0E-01	1.0E-02	--	1	1.0E-02

continued-

(a) Dermal RfD = (Oral RfD) x AF_o; dermal SF = (Oral SF)/AF_o; units are absorbed dose.
(b) Calculated by the following equation: Log K_p = -2.72 + 0.71 Log K_{ow} - 0.0061 MW (USEPA 1992b).
(c) Values for inorganic AF_o from Owen (1990) (arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, selenium and zinc), Seiler and Sigel (1988) (manganese), Friberg et al. (1986) (vanadium), or a default value (0.05) in the absence of compound specific data. Default value of 1.0 used for cyanide and all organics.
(d) Default value for inorganics (USEPA 1992a).

Table 4-3 - continued

Chemical	Oral			Dermal			Toxicokinetic Factors	
	RfD_S	RfD_C	SF	RfD_S	RfD_C	SF	AF_o	PC
ORGANICS - continued								
VOLATILES								
2-Butanone	5.0E-01	5.0E-02	--	5.0E-01	5.0E-02	--	1	1.1E-03
4-methyl-2-pentanone	5.0E-01	5.0E-02	--	5.0E-01	5.0E-02	--	1	2.8E-03
Acetone	1.0E+00	1.0E-01	--	1.0E+00	1.0E-01	--	1	5.7E-04
Benzene	--	--	2.9E-02	--	--	2.9E-02	1	2.1E-02
Bromodichloromethane	2.0E-02	2.0E-02	1.3E-01	2.0E-02	2.0E-02	1.3E-01	1	5.8E-03
Carbon disulfide	1.0E-01	1.0E-01	--	1.0E-01	1.0E-01	--	1	2.4E-02
Chlorobenzene	2.0E-01	2.0E-02	--	2.0E-01	2.0E-02	--	1	4.1E-02
Chloroform	1.0E-02	1.0E-02	6.1E-03	1.0E-02	1.0E-02	6.1E-03	1	8.9E-03
Ethylbenzene	1.0E+00	1.0E-01	--	1.0E+00	1.0E-01	--	1	7.4E-02
Methylene chloride	6.0E-02	6.0E-02	7.5E-03	6.0E-02	6.0E-02	7.5E-03	1	4.5E-03
Styrene	2.0E+00	2.0E-01	3.0E-02	2.0E+00	2.0E-01	3.0E-02	1	5.5E-02
Tetrachloroethene	1.0E-01	1.0E-02	5.1E-02	1.0E-01	1.0E-02	5.1E-02	1	4.8E-02
Toluene	2.0E+00	2.0E-01	--	2.0E+00	2.0E-01	--	1	4.5E-02
Trichloroethene	--	--	1.1E-02	--	--	1.1E-02	1	1.6E-02
Vinyl chloride	--	--	1.9E+00	--	--	1.9E+00	1	7.0E-03
Xylenes (total)	4.0E+00	2.0E+00	--	4.0E+00	2.0E+00	--	1	8.0E-02
SEMIVOLATILES								
Benzyl alcohol	1.0E+00	3.0E-01	--	1.0E+00	3.0E-01	--	1	2.5E-03
Benzoic acid	4.0E+00	4.0E+00	--	4.0E+00	4.0E+00	--	1	7.3E-03
bis(2-Ethylhexyl)phthalate	2.0E-02	2.0E-02	1.4E-02	2.0E-02	2.0E-02	1.4E-02	1	3.3E-03
Butylbenzylphthalate	2.0E+00	2.0E-01	--	2.0E+00	2.0E-01	--	1	2.4E-02
Chrysene	4.0E-01	4.0E-01	1.2E+01	NA	NA	NA	1	NA
1,4-Dichlorobenzene	--	--	2.4E-02	--	--	2.4E-02	1	6.2E-02
Diethylphthalate	8.0E+00	8.0E-01	--	8.0E+00	8.0E-01	--	1	4.8E-03
2,4-Dimethylphenol	2.0E-01	2.0E-02	--	2.0E-01	2.0E-02	--	1	1.5E-02
Dimethylphthalate	1.0E+00	1.0E+00	--	1.0E+00	1.0E+00	--	1	1.6E-03

continued-

Table 4-3 - continued

Chemical	Oral RfD_S	Oral RfD_C	Oral SF	Dermal RfD_S	Dermal RfD_C	Dermal SF	Toxicokinetic Factors AF_o	Toxicokinetic Factors PC
SEMIVOLATILES - continued								
Di-n-butylphthalate	1.0E+00	1.0E-01	--	1.0E+00	1.0E-01	--	1	4.9E-02
Di-n-octylphthalate	2.0E-02	2.0E-02	--	2.0E-02	2.0E-02	--	1	7.2E-03 (a)
2-methylphenol	5.0E-01	5.0E-02	--	5.0E-01	5.0E-02	--	1	1.0E-02
Phenol	6.0E-01	6.0E-01	--	6.0E-01	6.0E-01	--	1	5.5E-03
PESTICIDES/PCB's								
Aldrin	3.0E-05	3.0E-05	1.7E+01	3.0E-05	3.0E-05	1.7E+01	1	1.6E-03
beta BHC	--	--	1.8E+00	--	--	1.8E+00	1	2.1E-02
alpha Chlordane	6.0E-05	6.0E-05	1.3E+00	6.0E-05	6.0E-05	1.3E+00	1	8.9E+00
gamma Chlordane	6.0E-05	6.0E-05	1.3E+00	6.0E-05	6.0E-05	1.3E+00	1	9.8E+02
4,4-DDE	--	--	3.4E-01	--	--	3.4E-01	1	2.4E-01
4,4'-DDT	5.0E-04	5.0E-04	3.4E-01	5.0E-04	5.0E-04	3.4E-01	1	4.3E-01
Dieldrin	5.0E-05	5.0E-05	1.6E+01	5.0E-05	5.0E-05	1.6E+01	1	1.6E-02
Endosulfan II	2.0E-04	5.0E-05	--	2.0E-04	5.0E-05	--	1	2.3E-03
Heptachlor	5.0E-04	5.0E-04	4.5E+00	5.0E-04	5.0E-04	4.5E+00	1	1.1E-02
Polychlorined biphenyl (Aroclor 1248)	--	--	7.7E+00	--	--	7.7E+00	1	6.6E-01
NON-CLP CHEMICALS:								
Nitrogen, nitrate & nitrite	1.0E-01	1.0E-01	--	1.0E-01	1.0E-01	--	1	1.0E-03

(a) Log K_{ow} for bis(2-ethylhexyl) phthalate used as an estimate.

4.4 Chemicals with No Toxicity Values

Inspection of Tables 4-1 and 4-2 indicates that there are a number of chemicals for which there are no toxicity values. In the case of lead, considerable controversy exists concerning the appropriate toxicity value. In this risk assessment, lead was evaluated using the Uptake/Biokinetic (UBK) model (see Section 5.3). The potential risk of exposure to the other chemicals is not quantified and is addressed as a source of uncertainty in Section 6.0.

5.0 RISK CHARACTERIZATION

Risk characterization integrates the results of the exposure and toxicity assessments into a quantitative description of cancer and noncancer risk estimates. The method for risk characterization utilized in this baseline risk assessment is consistent with guidance provided in USEPA (1989a).

5.1 Evaluation of Carcinogenic Risks

The risk of cancer from exposure to a chemical is described in terms of the probability that an individual exposed for his or her entire lifetime will develop cancer by age 70. For each chemical of concern, this value is calculated from the daily intake, averaged over a lifetime (DI_L), and the SF for the chemical, as follows:

$$\text{Cancer Risk} = 1 - \exp(-DI_L \times SF) \qquad (3)$$

In most cases (except when the product of $DI_L \times SF$ is larger than about 0.01), excess cancer risk may be estimated more simply as:

$$\text{Cancer Risk} = DI_L \times SF \qquad (4)$$

Excess cancer risks are summed across all chemicals of potential concern and all exposure pathways that contribute to exposure of an individual in a given population. Typically, the USEPA requires remedial action at a site when total excess cancer risk levels to any current or future population exceed 1E-04 (USEPA 1991d).

Using the average lifetime daily intake values calculated as described in Section 3.3.2 and the slope factors described in Section 4.0 (Table 4-2), estimated cancer risks were calculated for populations assumed to be exposed at the Himco Dump site. Risk estimates for each population are summarized on Tables 5-1 through 5-3. The chemical- and medium-specific calculations are presented in Appendix 6. Due to the inherent uncertainty in cancer risk calculations, all risk values are reported to only one significant figure.

Estimated cancer risks to current populations are summarized in Table 5-1. There is no reason for concern for carcinogenic effects via these pathways. The risks to the nearest downwind resident from particulate and volatiles emissions from the site are estimated at 2E-07 for adults and 3E-06 for children. Risks to the dirt-bike rider are estimated at 4E-06. The estimated risks to the waders exposed at the quarry pit and ponds are 4E-08 and 2E-08, respectively.

Carcinogenic risks to hypothetical future residential populations are summarized in Table 5-2. Excess carcinogenic risks to hypothetical future

TABLE 5-1 SUMMARY OF ESTIMATED CARCINOGENIC RISK - CURRENT POPULATIONS

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Total Excess Cancer Risk
Dirt-bike rider	Site	Soil	Ingestion	2E-06
		Air	Inhalation - Particulates	2E-06
			Inhalation - VOCs	2E-08
			Total	4E-06
Wader	Quarry Pit	Surface Water	Ingestion	1E-08
			Dermal	4E-09
		Sediment	Ingestion	3E-08
			Total	4E-08
Wader	Ponds	Surface Water	Ingestion	1E-08
			Dermal	3E-09
		Sediment	Ingestion	8E-09
			Total	2E-08
Downwind off-site residents:				
Adult	Home	Air	Inhalation - Particulates	1E-07
			- Volatiles	7E-08
			Total	2E-07
Child	Home	Air	Inhalation - Particulates	1E-06
			- Volatiles	2E-06
			Total	3E-06

TABLE 5-2 SUMMARY OF ESTIMATED CARCINOGENIC RISK - HYPOTHETICAL FUTURE RESIDENTIAL POPULATIONS

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Total Excess Cancer Risk
Resident On Landfill:				
Adult	Home	Groundwater	Ingestion	1E-01
			Inhalation - VOCs	4E-04
			Dermal	1E-01
		Soil	Ingestion	5E-05
		Air	Inhalation - Particulates	1E-07
			Inhalation - VOCs	8E-07
			Total	2E-01
Child	Home	Groundwater	Ingestion	6E-02
			Inhalation - VOCs	2E-04
			Dermal	6E-01
		Soil	Ingestion	4E-05
		Air	Inhalation - Particulates	1E-07
			Inhalation - VOCs	2E-06
			Total	7E-01
Resident South of Landfill - Shallow Groundwater:				
Adult	Home	Groundwater	Ingestion	4E-03
			Inhalation - VOCs	6E-05
			Dermal	1E-04
		Soil	Ingestion	6E-04
			Total	5E-03
Child	Home	Groundwater	Ingestion	2E-03
			Inhalation - VOCs	4E-05
			Dermal	1E-03
		Soil	Ingestion	4E-04
			Total	3E-03
Resident South of Landfill - Deep Groundwater:				
Adult	Home	Groundwater	Ingestion	4E-03
			Inhalation - VOCs	6E-05
			Dermal	1E-04
		Soil	Ingestion	6E-04
			Total	5E-03
Child	Home	Groundwater	Ingestion	2E-03
			Inhalation - VOCs	3E-05
			Dermal	1E-03
		Soil	Ingestion	4E-04
			Total	3E-03

TABLE 5-3 SUMMARY OF ESTIMATED CARCINOGENIC RISK - HYPOTHETICAL FUTURE COMMERCIAL OR AGRICULTURAL USES

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Total Excess Cancer Risk
Plant Worker	Landfill	Groundwater	Ingestion	4E-02
		Soil	Ingestion	6E-06
		Air	Inhalation - Particulates	4E-08
			Inhalation - VOCs	2E-07
			Total	4E-02
Plant Worker	South of Landfill	Groundwater	Ingestion	1E-03
		Soil	Ingestion	6E-05
			Total	1E-03
Agricultural Worker	Landfill	Groundwater	Ingestion	3E-03
		Soil	Ingestion	4E-06
		Air	Inhalation - Particulates	5E-05
			Inhalation - VOCs	2E-09
			Total	3E-03
Downwind off-site resident:				
Adult	Home	Air	Inhalation - Particulates	1E-06
			- Volatiles	8E-07
			Total	2E-06
Child	Home	Air	Inhalation - Particulates	1E-06
			- Volatiles	2E-06
			Total	3E-06

residents living on the landfill and utilizing groundwater below the site are estimated at 7E-01 (children) to 2E-01 (adults). This risk is the result of exposures to groundwater contaminated with arsenic (3E-04), PAHs (2E-03) and vinyl chloride (1E-03). The remaining estimated carcinogenic risk is attributable to beryllium, which was not detected in leachate samples but was evaluated at one-half its detection limit.

If a residence were to be built just south of the landfill, use of groundwater in this area could pose a cancer risk of approximately 5E-03. As described previously, the method for calculating risks included the assumption that chemicals detected in soil or elsewhere in groundwater (including the leachate samples), but not in the wells located south of the landfill, were evaluated at one-half their detection limit (see Section 3.3.1). This assumption, then, conservatively assumes that the chemicals detected in soil or in groundwater beneath the landfill are not truly absent at downgradient locations, but are present at concentrations just below what the analytical laboratory can measure. Thus, the 5E-3 estimated cancer risk assumes the presence of all those chemicals detected in soil, leachate water or other groundwater samples. If these chemicals are truly absent, that is, the conditions below the landfill are such that these chemicals are not mobile and are not moving away from the landfill, then estimated risks would be much lower. Table 5-4 summarizes the 15 chemicals evaluated at one-half their detection limit, which contribute a carcinogenic risk of at least 1E-6 for hypothetical future residents south of the landfill. The table demonstrates that approximately 80% of the estimated risk downgradient of the landfill is attributable to these "nondetected" chemicals. If these chemicals are truly absent, total population cancer risks would be estimated at 1E-3 due primarily to the presence of arsenic and beryllium in groundwater and PAHs in soil.

Table 5-3 summarizes estimated cancer risks if future development of the site were commercial or agricultural instead of residential. If the future site use is commercial, a plant worker's excess cancer risk is estimated to range from 1E-03 to 4E-02 depending on whether a plant were built on or south of the landfill. As for residential populations, contaminated groundwater contributes the major portion of this risk.

If the site were to revert to agricultural uses, the risk to a hypothetical agricultural worker is estimated at 3E-03 due to contaminated groundwater ingested while working. Under a future agricultural land use condition, a downwind resident's risk due to increased mechanical erosion from tilling minimally affects risk estimates for downwind residents. These calculated risks (2E-06 to 3E-06) are within an acceptable risk range (i.e., they are less than 1E-04).

TABLE 5-4 SUMMARY OF CARCINOGENIC RISKS DUE TO NONDETECTED CHEMICALS

Chemical[a]	Estimated Carcinogenic Risk - South of Landfill[b]
1,1-Dichlorethene	5E-05
Aldrin	5E-06
alpha-Chlordane	3E-06
Benzo(a)pyrene	7E-04
Benzo(b)fluoranthene	7E-04
Benzo(k)fluoranthene	7E-04
Bromochloromethane	7E-06
Chloroform	8E-06
Chrysene	8E-04
Dieldrin	4E-05
gamma-Chlordane	3E-06
Indeno(1,2,3-cd)pyrene	7E-04
Styrene	2E-06
Tetrachloroethlene	3E-06
Vinyl chloride	1E-04
Total, Nondetected Chemicals:	4E-03
Total, All Chemicals :	5E-03

(a) Chemicals detected in soil or groundwater (at other sampling locations) and assumed to be present (i.e., evaluated at one-half their reported detection limit).
(b) Analysis for adult resident only, utilizing shallow groundwater.

5.2 Evaluation of Noncarcinogenic Effects

The potential for noncarcinogenic effects is evaluated by comparing an estimated intake for a chemical over a specific time period with the RfD for that chemical derived from a similar exposure period. This comparison results in a noncancer hazard quotient as follows:

$$HQ = DI/RfD \tag{5}$$

where:

HQ = Hazard Quotient for subchronic (HQ_s) or chronic (HQ_c) exposure
DI = Daily Intake (mg/kg-day), either from subchronic (DI_S) or chronic (DI_C) exposure
RfD = Reference Dose (mg/kg-day), either for subchronic (RfD_s) or chronic (RfD_c) exposure

Since exposure occurs simultaneously to more than one chemical, HQ values are summed as follows:

$$HI = HQ_1 + HQ_2 + HQ_3 \ldots\ldots HQ_i \tag{6}$$

where:

HI = Screening level hazard index for either subchronic or chronic exposure
HQ_1 = Hazard Quotient for the first chemical
HQ_i = Hazard Quotient for the ith chemical

The HQ values all represent the same exposure period and are summed for all chemicals and all pathways that contribute to the exposure of an individual in a given population. If the screening level HI is equal to or less than one (1E+00), it is believed noncarcinogenic health effects will not occur. If an HI exceeds 1E+00, there is some possibility that noncarcinogenic effects could exist although an HI above 1E+00 does not indicate an effect will occur. In particular, the screening level approach assumes that all noncancer effects are additive. However, in some cases, effects caused by one chemical on a particular tissue (e.g., the liver) will not be influenced by the effects of another chemical on a different tissue (e.g., the kidney). Thus, when the screening level HI exceeds 1E+00, it may be necessary to perform a more detailed analysis in which effects are summed after segregation according to target tissue (USEPA 1989a).

The methods for calculation of average daily intakes (DI_S and DI_C) were summarized in Section 3.3.2, and chemical-specific RfD values were summarized in Table 4-1. Based on these, HQ and HI values for subchronic (HI_S) and chronic (HI_C) exposures were calculated for each exposure scenario evaluated at this site. Because of the uncertainty inherent in calculation of HQ values, all HQs are reported to only one significant figure. The detailed calculations are presented in Appendix 5 and results are summarized in Tables 5-5 through 5-7.

All estimated noncarcinogenic risks for current populations are well below a level of concern. However, for all assumed future residential and worker populations that include a groundwater pathway (except for the plant worker, south of the landfill) hazard indices exceed 1E+00.

Subchronic hazard indices for child residents range from 10 to 1,000; chronic hazard indices range from 5 to 500 for adult residential populations. Antimony is the primary contributor to this risk. Other chemicals whose hazard quotients exceed 1.0 include arsenic, beryllium, cadmium, chromium, vanadium, alpha-chlordane and nitrate/nitrite.

As was done for carcinogenic risks, the effect of "nondetected" chemicals on the calculation of HI values was analyzed. There are relatively few chemicals with noncarcinogenic health effects which, when evaluated at one-half their detection limit, will give an HQ greater than one. Alpha-chlordane, beryllium and nitrate/nitrite are the only three chemicals of potential concern at Himco where this is an issue. Nitrate/nitrite was not detected in the shallow groundwater, yet when evaluated at one-half its detection limit, would result in an estimated HQ of 10 (half of the HI value of 20 estimated for child resident population). Beryllium was not detected in leachate samples (and was therefore evaluated at one half its detection limit) and the resulting HQ of 100 is 10% of the total HI of 1,000 (child resident). For child residential populations south of the landfill, the assumption that alpha-chlordane is present results in an HQ of 3 for this chemical (the HI is 20).

The only nongroundwater pathway contributing unacceptable noncarcinogenic risk is the air particulate pathway for the hypothetical future agricultural worker. A chronic hazard index of 4E+00 was calculated for this pathway. This risk is due entirely to chromium.

Since each chemical itself contributes an HQ greater than 1E+00, there is no need to segregate chemicals by effect.

5.3 Evaluation of Risks from Lead Exposure

Since there are no EPA-approved RfD values for lead, it is not possible to evaluate the noncancer risks of lead by calculation of a HI. An alternative approach is to estimate the likely effect of lead exposure on the concentration of lead in the blood (PbB). Several mathematical models have been developed for calculating the value of PbB as a function of environmental concentrations of lead (USEPA 1989c). Of these, the Uptake/Biokinetic (UBK) model has the greatest flexibility and has been most thoroughly validated, so it is selected for use here. The basic equation for calculating PbB with the UBK model is:

$$PbB = (\Sigma\ C_i \times I_i \times ABS_i) \times BKSF \qquad (7)$$

TABLE 5-5 SUMMARY OF NONCARCINOGENIC RISK - CURRENT POPULATIONS

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Hazard Index Subchronic	Hazard Index Chronic
Dirt-bike Rider	Site	Soil	Ingestion	--[(a)]	7E-03
		Air	Inhalation - Particulates	--	2E-01
			Inhalation - VOCs	--	3E-05
			Total	--	2E-01
Wader	Quarry Pit	Surface Water	Ingestion	5E-04	--
			Dermal	4E-04	--
		Sediment	Ingestion	1E-03	--
			Total	2E-03	--
Wader	Ponds	Surface Water	Ingestion	3E-04	--
			Dermal	5E-04	--
		Sediment	Ingestion	2E-04	--
			Total	1E-03	--
Downwind off-site resident:					
Adult	Home	Air	Inhalation - Particulates	--	1E-01
			- Volatiles	--	1E-03
			Total	--	1E-01
Child	Home	Air	Inhalation - Particulates	6E-02	--
			- Volatiles	1E-02	--
			Total	7E-02	--

(a) Exposure not evaluated for this population.

TABLE 5-6 SUMMARY OF NONCARCINOGENIC RISK - HYPOTHETICAL FUTURE RESIDENTIAL POPULATIONS

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Hazard Index[(a)]
Resident On Landfill:				
Adult	Home	Groundwater	Ingestion	5E+02
			Inhalation - VOCs	2E+00
			Dermal	2E+01
		Soil	Ingestion	2E-01
		Air	Inhalation - Particulates	1E-02
			Inhalation - VOCs	1E-03
			Total	5E+02
Child	Home	Groundwater	Ingestion	9E+02
			Inhalation - VOCs	4E+00
			Dermal	1E+02
		Soil	Ingestion	8E-01
		Air	Inhalation - Particulates	7E-03
			Inhalation - VOCs	1E-02
			Total	1E+03
Resident South of Landfill - Shallow Groundwater:				
Adult	Home	Groundwater	Ingestion	9E+00
			Inhalation - VOCs	2E-01
			Dermal	8E-01
		Soil	Ingestion	1E-01
			Total	1E+01
Child	Home	Groundwater	Ingestion	2E+01
			Inhalation - VOCs	2E-01
			Dermal	3E+00
		Soil	Ingestion	5E-01
			Total	2E+01
Resident South of Landfill - Deep Groundwater:				
Adult	Home	Groundwater	Ingestion	4E+00
			Inhalation - VOCs	2E-01
			Dermal	9E-01
		Soil	Ingestion	1E-01
			Total	5E+00
Child	Home	Groundwater	Ingestion	9E+00
			Inhalation - VOCs	2E-01
			Dermal	4E+00
		Soil	Ingestion	5E-01
			Total	1E+01

(a) Hazard index is subchronic for child populations and chronic for all others.

TABLE 5-7 SUMMARY OF ESTIMATED NONCARCINOGENIC RISK - HYPOTHETICAL FUTURE COMMERCIAL OR AGRICULTURAL POPULATIONS

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Hazard Index[(a)]
Plant Worker	Landfill	Groundwater	Ingestion	1E+02
		Soil	Ingestion	3E-02
		Air	Inhalation - Particulates	3E-03
			Inhalation - VOCs	3E-04
			Total	1E+02
Plant Worker	South of Landfill	Groundwater	Ingestion	1E+00
		Soil	Ingestion	2E-02
			Total	1E+00
Agricultural Worker	Landfill	Groundwater	Ingestion	1E+01
		Soil	Ingestion	2E-02
		Air	Inhalation - Particulates	4E+00
			Inhalation - Volatiles	4E-06
			Total	1E+01
Downwind off-site resident:				
Adult	Home	Air	Inhalation - Particulates	1E-01
			- Volatiles	1E-03
			Total	1E-01
Child	Home	Air	Inhalation - Particulates	5E-02
			- Volatiles	1E-02
			Total	6E-02

(a) Hazard index is subchronic for child populations and chronic for all others.

where:

C_i = Concentration of lead in medium i (µg/unit medium)
I_i = Human intake of medium i (units medium/day)
ABS_i = Absorption fraction of lead from medium i (unitless)
BKSF = Biokinetic slope factor relating blood lead to absorbed dose. The units of BKSF are µg/dL per µg/day

In general, the values of I, ABS and BKSF are all age dependent, and the value of PbB at any given age is a complex function of both current and past lead exposure levels. It is commonly agreed that young children are more susceptible to the effects of lead than older children or adults, since young children tend to have higher exposure levels (especially to soil), young children have higher lead absorption rates and the nervous system of infants and young children is more sensitive to the neurological effects of lead.

The USEPA has developed a computer program ("LEAD5") for calculating lead exposure and resulting PbB values for children age zero to six years. This computer program was used to evaluate the effects of lead in environmental media on children at this site. The calculations include lead exposure from all sources (including food and area-wide emissions to air), and not just those specifically derived from the site (soil, water and/or air). Most input parameters (e.g., body weight, water intake, soil intake, breathing rate and lead intake from the diet) were taken to be the national average values suggested as defaults by the USEPA. The concentrations of lead in soil and water were site-specific average (not AM_{95}) values calculated as detailed in Appendix 5 for the specific exposure scenarios. The concentrations of air for those populations exposed to site emissions were site-specific average values plus the concentration of the default exposure, assuming the site emissions are episodic increases of lead concentrations in air due to wind and vehicular erosion.

Although there is no universally agreed upon value of PbB that may be identified as "safe" for the effects of lead on children, the USEPA has identified 10 µg/dL as the level of concern for health effects in children that warrants avoidance (USEPA 1988e). The USEPA also recommends that, for a given exposed population of children, no more than 5% should exceed the 10 µg/dL level. Table 5-8 summarizes the predicted geometric mean blood lead level and the percentile of the population predicted to exceed 10 µg/dL for each exposed population. As shown in Table 5-8, geometric blood lead values are predicted to range from 3 to 100 µg/dL for the various populations. It appears that the lead in groundwater beneath the landfill area is a cause for concern at this site.

5.4 Evaluation of Risks by Source

In this risk characterization, risk estimates have been calculated without regard to the source of the contamination. That is, all chemicals detected during the RI sampling were assumed to be site-related. Thus the risk estimates represent total risk to the assumed exposed populations. There is some question as to whether some of the calculated risks could be attributable

TABLE 5-8 SUMMARY OF RISKS TO CHILDREN FROM EXPOSURE[a] TO LEAD

Population	Location-Specific Data			Mean PbB, µg/dL	% Population above 10 µg/dL
	Water Lead Conc., µg/L	Soil Lead Conc., µg/g	Air Lead Conc., µg/m^3		
Current Populations:					
Downwind Child Resident	--	--	0.2	3.24	0.06
Future Populations:					
Child Resident South of Landfill					
- shallow well	50	73	--	5.12	2.7
- deep well	2.1	73	--	2.04	0
Child Resident on Landfill	5,100	2.5	0.2	106.01	100

(a) The following default values were used when location-specific data were not available: Air = 0.2 mg/m^3, Water = 4 µg/L, Soil = 200 µg/g, Food = 6.38 µg/day.

to background, either natural or relative to other sources. In an effort to quantify background risk, risk estimates were developed for exposures to samples from background groundwater and soil locations (as described in Section 2.0) for an assumed hypothetical future adult residential scenario. These results are summarized on Table 5-9. Arsenic, beryllium, bromodichloromethane, chloroform and bis(2-ethylhexyl)phthalate were detected in background groundwater at concentrations that contribute excess cancer risk in the range of 6E-4. Arsenic and nitrate/nitrite dominate the noncarcinogenic risks. The source of the arsenic and beryllium appears to be natural; the source of the nitrate/nitrite is unknown but may be related to the previous agricultural use of the site. The source of the other organic chemicals is presently unknown.

5.5 Risk Summary

The greatest cause for health concern at the Himco site is the hypothetical future use of groundwater below the landfill. Risks from ingestion, dermal contact and inhalation of volatiles from this groundwater present carcinogenic risks in the range of 1E-01 (although a significant portion of this risk is due to undetected beryllium, assumed to be present). Hazard index values for these pathways are approximately 500 to 1,000. Further downgradient of the landfill (south), the estimated excess cancer risks to a future resident are approximately 5E-3. Virtually all this risk, however, is attributable either to chemicals not detected, but conservatively evaluated as if they were present, or to chemicals attributable to upgradient or background sources. It therefore appears that although groundwater beneath the landfill is contaminated, this contamination has not moved (or at least has not been detected) at downgradient exposure points south of the landfill or has been diluted to undetectable levels.

In addition to groundwater, there is an estimated excess cancer risk of 4 to 6E-04 to a future resident living south of the landfill where PAHs were detected in the soil. If the site were to revert to an agricultural use, there could be cause for concern via tilling due to chromium present in the landfill soil at a level (4.7 mg/kg) below that detected in background (7.1 mg/kg).

Other future land uses which do not involve groundwater and current uses of the site do not present excess cancer risks greater than 1E-04 or hazard indices greater than 1E+00.

TABLE 5-9 COMPARISON OF TOTAL SITE AND BACKGROUND RISKS

Exposure Routes	Estimated Carcinogenic Risk: Background[a]	Estimated Carcinogenic Risk: Total Site: Shallow Well[b]	Estimated Carcinogenic Risk: Total Site: Deep Well[b]	Estimated Carcinogenic Risk: Landfill Area	Estimated Noncarcinogenic Risk: Background[a]	Estimated Noncarcinogenic Risk: Total Site: Shallow Well[c]	Estimated Noncarcinogenic Risk: Total Site: Deep Well[c]	Estimated Noncarcinogenic Risk: Landfill Area[d]
Groundwater								
- Ingestion	3E-04	4E-03	4E-03	1E-01	6E+00	9E+00	4E+00	5E+02
- Inhalation-VOCs	9E-06	6E-05	6E-05	4E-04	8E-04	2E-01	2E-01	2E+00
- Dermal	3E-04	1E-04	4E-04	1E-01	1E-01	8E-01	9E-01	2E+01
Soil								
- Ingestion	1E-05	6E-04	6E-04	5E-05	5E-02	1E-01	1E-01	2E-01
Total	6E-04	5E-03	5E-03	2E-01	6E+00	1E+01	5E+00	7E+02

(a) Calculated using background soil samples (HDGT-02A, 04A, OGA) and wells upgradient of site (WT102A-C, WTB). Evaluated for future on-site adult resident. Detailed calculations in Appendix 5.
(b) From Table 5-2.
(c) From Table 5-2.
(d) From Table 5-6.

6.0 ASSESSMENT OF UNCERTAINTIES

There are a number of factors that contribute uncertainty to the estimates of exposure and risk. The most important of these are discussed in this Section.

Selection of Contaminants of Potential Concern

The selection of contaminants of potential concern was designed to include all chemicals identified at the site that are most likely to be of human health concern. Two procedures were used to eliminate chemicals (nondetection and nutritional essentiality). The chemicals not selected because of nutritional essentiality have low toxicity and their elimination is unlikely to result in an underestimation of risk. Elimination of the remaining chemicals because they were not detected in any environmental sample is, however, a source of some uncertainty, because of the possibility that some of these chemicals may actually have been present, but at levels below detection limits. To evaluate the magnitude of the uncertainty associated with excluding these chemicals, a calculation was performed to determine the risk these chemicals might pose if they were indeed present at the detection limit (Table 6-1). This table evaluates the chemicals never detected at Himco for which excess lifetime cancer risks would equal or exceed 1E-06 either in groundwater or soil assuming the dominant pathways quantified in this risk assessment. For hexachlorobenzene in groundwater there may be some concern since this risk estimate exceeds 1E-04.

It is important to remember that there is no reason to believe these chemicals are actually present at Himco at least at levels approaching detection limits. Nonetheless, this is a source of uncertainty that could result in an underestimate of risk.

Another source of uncertainty is the potential risk posed by exposure to tentatively identified compounds in groundwater, soil and sediment. The identity, concentration and toxicity of these chemicals are uncertain and therefore were not evaluated.

Exposure Pathways Not Evaluated

Not all potentially complete exposure pathways were quantified at this site. Each of these pathways does contribute some risk and, therefore, may lead to an underestimate of risk. Since total risk to a human is a sum of all complete pathways known to exist, the lack of quantification of these pathways may underestimate risk. It is believed that those pathways not quantified generally represent small sources of exposure.

Ingestion of home-grown crops (vegetables or fruits) contaminated by bioaccumulation of chemicals in soil or deposition of particulates onto plant leaves was not evaluated. The uptake of contaminants by plants is subject to considerable uncertainty (USEPA 1991c). Additional uncertainty results from determining exposure point concentrations because it is likely contaminated soils would be tilled, fertilized and mixed with soil enhancers (such as peat, manure, etc.). The underestimate of risk from not evaluating this pathway

TABLE 6-1 ESTIMATED CANCER RISK AT THE DETECTION LIMIT FOR CHEMICALS NEVER DETECTED

Chemical	Water: Maximum U-Value[(a)] Groundwater, mg/L	Water: Cancer Risk[(b)]	Soil: Maximum U-Value Soil, mg/kg	Soil: Cancer Risk[(c)]
1,1,2,2-Tetrachloroethane	1.0E-02	7E-05	4.0E-02	8E-09
1,2-Dichloroethane	1.0E-02	3E-05	4.0E-02	4E-09
2,4-Dinitrotoluene	1.1E-02	8E-05	1.1E+00	1E-06
2,4,6-Trichlorophenol	1.1E-02	1E-06	1.1E+00	2E-08
2,6-Dinitrotoluene	1.1E-02	8E-05	1.1E+00	1E-06
3,3'-Dichlorobenzidine	2.2E-02	1E-04	2.2E+00	2E-06
bis(2-Chloroethyl) ether	1.1E-02	1E-04	1.1E+00	2E-06
Bromoform	1.0E-02	2E-06	4.0E-02	5E-10
Carbon tetrachloride	1.0E-02	4E-05	4.0E-02	8E-09
Chloromethane	1.0E-02	3E-06	4.0E-02	8E-10
Dibromochloromethane	1.0E-02	9E-06	4.0E-02	5E-09
Heptachlor epoxide	5.0E-04	5E-05	2.6E-02	2E-07
Hexachlorobenzene	1.1E-02	2E-04	1.1E+00	2E-06
Hexachlorobutadiene	1.1E-02	9E-06	1.1E+00	1E-07
Hexachloroethane	1.1E-02	2E-06	1.1E+00	2E-08
Pentachlorophenol	5.4E-02	7E-05	5.2E+00	1E-06
Polychlorinated biphenyls	1.1E-03	9E-05	7.2E-01	9E-06
Toxaphene	5.0E-03	6E-05	1.8E+00	3E-06

(a) U-Value is reported concentration associated with the highest U-value.
(b) Risk calculated by assuming ingestion of water by an adult plus inhalation of VOCs (USEPA 1989a).
(c) Risk calculated by assuming ingestion of surface soil only.

could potentially be substantial, since a reasonable maximum value for home-grown vegetable consumption is 80 g/day (USEPA 1989a), which is 800 times greater than the reasonable maximum value for ingestion of soil by adults. Therefore, for any contaminant that accumulates with a ratio greater than 1:800 in vegetables compared to soil, the home-grown produce pathway could dominate risk.

Environmental Fate and Transport

The evaluation of human health risks assumed that environmental media concentrations determined from sampling will remain at the same levels over a the assumed periods of exposure. This assumption is likely to result in an overestimate of risk, since concentrations, especially of organic contaminants, are expected to decline over the long-term as natural fate and transport processes degrade, dilute or remove site contaminants. The rate of the degradation, removal and/or dilution of chemicals in soil, groundwater, surface water and sediment is not known therefore the magnitude of the overestimate is difficult to estimate.

On the other hand, if contaminants only detected in leachate during the RI begin to move to downgradient wells for some reason (for instance, an increase in pumping in the area because of commercial or residential development), then risks to those populations south of the landfill could be underestimated. It is unlikely, however, that those risks would be higher than the risks calculated from exposure to groundwater directly below the landfill (as represented by the leachate samples).

Estimation of Exposure Point Concentrations

The exposure point concentrations used for assessing risks are the upper 95th confidence limit of the arithmetic mean values of measured concentrations or the maximum detected value if the upper 95th confidence limit exceeded the maximum detected value. Nondetected values were treated as concentrations equal to either zero or half the detection limit. This procedure could underestimate or overestimate risk depending on the actual concentrations (if present) of the chemical reported below the detection limits. This uncertainty is most likely when estimating concentrations for those chemicals detected infrequently.

At the Himco Dump site, the fate and transport of specific chemicals is not fully characterized. The evidence indicates that contamination is migrating from soil to groundwater. Therefore, any chemical of potential concern in soil was also evaluated in groundwater. In addition, it is evident that the highest level of contaminantion occurs in leachate water. Chemicals detected in leachate samples, but not detected in groundwater samples down gradient of the landfill were evaluated at one-half their detection limit. This assumption could over or underestimate risk depending on whether those chemicals are not moving toward those wells or whether they are indeed present downgradient at levels below laboratory detection limits. All other detected chemicals of potential concern were evaluated dependent on their detection in that medium. This may result in an underestimate of risk.

An additional uncertainty is introduced by the use of surface soil concentrations for calculating daily intake resulting from incidental ingestion of soil/dust by hypothetical future adult and child residents. The assumption --that all ingested soil is as contaminated as surface soil near a future residence-- increases the conservatism of the risk assessment by an amount that is dependent upon the actual fraction of ingested soil that is not contaminated by site-related chemicals.

Soil Sampling and Quantification of Exposure

Surficial soil from zero to six to twelve inches is the depth of soil considered most likely to be available for exposure. However, at this site the surficial soil samples utilized in this risk assessment were taken up to 24 inches in depth and samples taken in the landfilled area were taken three to nine inches below the cover material. The quantification of soil exposures assuming all surficial soil is available for contact or intake may over-estimate or underestimate risk.

It should also be noted that the assumption that exposure to soils would be limited to surficial depths may underestimate risk because of the nature of contamination at this site, i.e., several volatile and semivolatile chemicals increase in concentration with depth. Thus, if any future activities brought subsurface soil to the surface, risks could be higher.

Exposure Levels

The amount of exposure which an individual receives is highly dependent on the details related to their human activity patterns. As discussed in Section 3.3.2, there is considerable uncertainty regarding the values assumed in calculating human intake factors. For instance, estimates of soil ingestion rates for all populations is subject to on-going debate.

When faced with significant uncertainties in the appropriate values to use in the derivation of HIF terms, an effort was made to employ conservative (but not entirely unrealistic) and standard (USEPA 1991c) values. As a result of this approach, it is likely that some calculated estimates of risk are higher than actual, but it is unlikely that any of the calculated risks are significantly lower.

Bioavailability

When chemicals are present in soil, the amount absorbed into the body when the soil is ingested or inhaled may be less than the amount absorbed when the chemicals are administered in pure form. Thus, the actual dose may be lower for exposed humans than for the experimental animals upon which most toxicity values are based. This may be particularly true for metals. No correction for bioavailability has been made in this assessment which may result in some overestimate of risk.

Concentration of Volatiles from Household Uses of Water

Inhalation of volatiles released from groundwater via household uses was evaluated by assuming that the intake was twice that from ingestion of water. Actual worst-case estimates typically range from one to six times ingestion exposure. The value of two times ingestion exposure may underestimate risk to individuals with high water usage in poorly ventilated homes.

Assumptions and Parameters Used in Modeling the Air Pathway

When models are used to calculate exposure point concentrations, uncertainty is generated as a result of limitations in the models themselves and because of the uncertainty in the assumptions and the input parameters used.

Estimates of PM_{10} concentrations (Appendix 2) in air resulting from wind and vehicular (dirt-bikes and tractors) erosion of particles from site soils are highly uncertain. This is mainly the result of the lack of site-specific data and the need to employ assumed input parameters. Site-specific information on the area of the site that is disturbed (or would be likely to be disturbed in the hypothetical agricultural scenario) and the number and frequency of site disturbances is unknown. The lack of site information increases the inherent uncertainty of the model which is intended to provide no more than rough estimates.

In the case of inhalation exposure to volatiles released from soil, the risks are sufficiently small that uncertainties in the approach to estimate exposure (Appendix 3) would not significantly influence risk conclusions. For inhalation exposures to volatiles released from groundwater during indoor water usage, risks may be significant and any uncertainties in those calculations could influence subsequent risk estimates.

Absence of Toxicity Values

Quantification of risk from exposure to a chemical cannot be accomplished in the absence of reliable, appropriate toxicity values (reference doses, slope factors) for all routes and exposure periods. For the chemicals of potential concern at the Himco Dump site, toxicity values are not available for some chemicals by some routes. The absence of these values is likely to result in an underestimate of both noncancer and cancer health risks at this site, but is not possible to estimate the magnitude of this underestimate.

Cancer Risk Estimates

The predicted cancer risk due to chemical exposure is often based on cancer dose-response data in animals. There is a long-standing controversy in the scientific community as to the best way by which animal data should be extrapolated to humans. In general, the USEPA follows a conservative procedure in the derivation of slope factors, so cancer risk estimates based on these values could be considerably higher than the true risk.

The cancer risks calculated for children are less certain than those calculated for adults. The method utilized in this risk assessment assumes cancer risks are simply proportional to total dose. Actual cancer risk to a child exposed only in childhood could be higher or lower depending on the detailed mechanism of carcinogenicity for each chemical.

Exposure to Multiple Chemicals

The HI approach assumes that risks from multiple chemicals are additive, ignoring both synergistic and antagonistic effects among chemicals. There is no evidence of synergism among the chemicals evaluated at the Himco Dump site, therefore, the assumption of dose additivity is not likely to be a source of major error.

Summary of Uncertainty

In summary, the estimation of exposure and risk are subject to a number of uncertainties that may lead to either an overestimate or underestimate of risk.

Assumptions made in this risk assessment that are likely to overestimate risk include:

- Environmental media concentrations are unchanged over time.
- All ingested soil comes from the contaminated source.
- Soil is ingested at the assumed rates for all exposed populations.
- Human activity patterns and the resultant exposure factors used to calculate a reasonable maximum exposure are as assumed.
- Slope factors are equal to the 95% confidence limit of the best estimate of the slope of the dose-response curve.

Factors in this risk assessment that are likely to underestimate risk:

- Not all exposure pathways for all chemicals were quantified.
- Toxicity values are not available for every chemical, for every exposure duration or for all exposure routes.
- Chemicals not detected in any media, but possibly present, were not quantified.
- Risks from all TICs were not quantitatively evaluated.
- Risks for chemicals not analyzed for, but possibly present, were not evaluated.

Factors in which the direction of the uncertainty cannot be determined or are unknown include:

- Use of zero or one-half detection limit in calculating exposure point concentrations for samples where a specific chemical was not detected.
- Analytical variations in chemical analyses.
- Lack of information on the interactions among the multiple chemicals contributing to noncancer and cancer risks.
- Assumption of all hypothetical future populations and activities.
- All modeling assumptions and input parameters.
- Method for quantifying less than lifetime exposures to carcinogens (e.g., in childhood).

7.0 SUMMARY

This baseline risk assessment is an analysis of the potential adverse health effects resulting from exposures to contaminants at the Himco Dump site. The site is a closed landfill located in the city of Elkhart, Indiana. The landfill wastes consist primarily of pharmaceutical wastes and calcium sulfate.

The basic methodology used in this risk assessment was developed by the USEPA specifically for evaluation of risk at hazardous waste sites. A baseline risk assessment considers conditions in the absence of any remedial actions to control or mitigate releases (including institutional controls), that is, the no-action alternative. Overall, the methodology used in a baseline risk assessment is intentionally conservative, meaning that the true risks from the site are unlikely to be higher than the derived estimates, and are most likely to be lower. The major elements in this risk assessment are summarized below.

7.1 Selection of Chemicals of Potential Concern

Analytical data on chemical concentrations in soil, groundwater, surface water and sediment were evaluated to identify the chemicals that would form the focus of the quantitative risk assessment.

Chemicals were eliminated from the quantitative risk assessment if they were not detected in any environmental sample or if they were beneficial human nutrients and occurred at levels that did not exceed the beneficial level. The chemicals selected as chemicals of potential concern are listed in Table 7-1.

7.2 Exposure Scenarios Evaluated

An analysis of exposure pathways along with probable human activity patterns, current and future land uses and site contamination was completed to determine complete exposure pathways and to select exposure scenarios for quantification.

Current populations most likely to be exposed are:

- Residents northeast of the site
- Recreational dirt-bike riders
- Recreational visitors (waders, fishers)

Hypothetical future use of the site could include agricultural use or commercial/residential development. The hypothetical future populations most likely to be exposed are:

- Site residents
- Plant workers on site
- Agricultural workers on site
- Downwind off-site residents

TABLE 7-1 CHEMICALS OF POTENTIAL CONCERN - HIMCO DUMP SITE

INORGANICS:

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Cobalt
Iron
Lead
Mercury
Nickel
Silver
Thallium
Vanadium
Cyanide

ORGANICS:

VOLATILES

1,1-Dichloroethane
1,1-Dichloroethene
1,1,1-Trichloroethane
1,2-Dichloroethene
2-Butanone
2-Hexanone
4-methyl-2-pentanone
Acetone
Benzene
Bromodichloromethane
Carbon disulfide
Chlorobenzene
Chloroethane
Chloroform
Ethylbenzene
Methylene chloride
Styrene
Tetrachloroethene
Toluene
Trichloroethene
Vinyl chloride
Xylenes

SEMIVOLATILES

1,4-Dichlorobenzene
2,4-Dimethylphenol
2-Methylnaphthalene
2-Methylphenol
4-Methylphenol
Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(g,h,i)perylene
Benzoic Acid
Benzyl alcohol
bis(2-Ethylhexyl) phthalate
Butylbenzylphthalate
Carbazole
Chrysene
Dibenz(a,h)anthracene
Dibenzofuran
Diethylphthalate
Dimethylphthalate
Di-n-butylphthalate
Di-n-octylphthalate
Fluoranthene
Fluorene
Indeno(1,2,3-cd) pyrene
Naphthalene
Phenanthrene
Phenol
Pyrene

PESTICIDES/PCB's

4,4'-DDT
4-4'-DDE
Aldrin
alpha-BHC
alpha-Chlordane
beta-BHC
Dieldrin
Endosulfan II
gamma-Chlordane
Heptachlor
Polychlorinated biphenyls (Aroclor 1248)

NON-CLP CHEMICALS:

Bromide, dissolved
Chloride
Nitrogen, ammonia
Nitrogen, nitrate & nitrite
Phosphorus
Sulfate

While other exposure pathways may also exist at this site, they were judged to be relatively minor when compared to those pathways which were quantified. The exposure scenarios that were quantified are listed in Table 7-2.

Each pathway was quantified by:

- Estimating an exposure point concentration (generally the 95th upper confidence limit of the arithmetic average of all samples representative of a given exposure point).
- Estimating a human intake factor which combines all the variables involved in exposure to a contaminant (i.e., ingestion or inhalation rate, exposure duration and frequency, body weight, averaging time).
- Comparing the product of the above (the subchronic, chronic and lifetime daily intakes) to an appropriate toxicity value.

7.3 Risk Summary

Cancer Risks

The risk of cancer from an exposure to a chemical is described in terms of the probability that an individual exposed for a lifetime will develop cancer. Typically, the USEPA requires remediation when total excess cancer risks levels exceed 1E-04 for a given population. Higher cancer risk levels may be a cause for concern. Cancer risks estimated for the Himco Dump site are summarized on Tables 7-3 through 7-5. Due to the inherent uncertainty in cancer risk calculations all risk values are reported to only one significant figure.

Estimated risks for current populations range from 2E-08 (wader) to 4E-06 (dirt bike rider). Estimated cancer risks for future populations are highest for a resident living in a home built on the landfill (7E-01, children; 2E-01, adults). Virtually all of this risk is from groundwater pathways. The major contributors are arsenic, beryllium, PAHs and several volatile organic compounds.

Noncancer Risks

The potential for noncarcinogenic effects is evaluated by summing the ratios of chemical-specific intake over a specific time period to the chemical-specific RfDs derived for a similar exposure period. This cumulative ratio is referred to as a HI. Since some individuals are exposed by more than one pathway, HI values are summed for each pathway that contributes to the exposure of an individual in a given population. If the total HI is equal to or less than 1 (1E+00), it is believed noncarcinogenic health effects will not occur. If a HI exceeds 1E+00, there is some possibility that noncarcinogenic effects may exist although a HI above 1E+00 does not indicate an effect will occur. In particular, summing values assumes that all noncancer effects are additive. Since this is not always true, when a population total HI exceeds 1E+00, it may be appropriate to re-examine the noncancer effects for that

TABLE 7-2 SUMMARY OF EXPOSURE PATHWAYS SELECTED FOR QUANTIFICATION

Land Use	Potentially Exposed Population	Exposure Point	Exposure Medium	Exposure Route
Current	Dirt-bike rider	Site	Soil	Ingestion
			Air	Inhalation - Particulates - VOCs
	Wader	Surface water on site (ponds or quarry pit)	Surface water	Ingestion Dermal contact
			Sediment	Ingestion
	Residents (child and adult) northeast of site	Closest downwind residence northeast of site	Air	Inhalation - Particulates - VOCs
Hypothetical Future	Residents (child and adult)	Residence on landfill or south of landfill area	Soil	Ingestion
			Groundwater	Ingestion Inhalation-VOCs Dermal
	Workers	Plant or office facility on landfill or south of landfill area	Soil	Ingestion
			Groundwater	Ingestion
	Agricultural Workers	On landfill area	Soil	Ingestion
			Air	Inhalation - Particulates - VOCs
			Groundwater	Ingestion
	Residents (child and adult) northeast of site	Closest downwind residence northeast of site (assuming future agricultural development)	Air	Inhalation - Particulates - VOCs

TABLE 7-3 SUMMARY OF ESTIMATED CARCINOGENIC RISK - CURRENT POPULATIONS

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Total Excess Cancer Risk
Dirt-bike rider	Site	Soil	Ingestion	2E-06
		Air	Inhalation - Particulates	2E-06
			Inhalation - VOCs	2E-08
			Total	4E-06
Wader	Quarry Pit	Surface Water	Ingestion	1E-08
			Dermal	4E-09
		Sediment	Ingestion	3E-08
			Total	4E-08
Wader	Ponds	Surface Water	Ingestion	1E-08
			Dermal	3E-09
		Sediment	Ingestion	8E-09
			Total	2E-08
Downwind off-site residents:				
Adult	Home	Air	Inhalation - Particulates	1E-07
			- Volatiles	7E-08
			Total	2E-07
Child	Home	Air	Inhalation - Particulates	1E-06
			- Volatiles	2E-06
			Total	3E-06

TABLE 7-4 SUMMARY OF ESTIMATED CARCINOGENIC RISK - HYPOTHETICAL FUTURE RESIDENTIAL POPULATIONS

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Total Excess Cancer Risk
Resident On Landfill:				
Adult	Home	Groundwater	Ingestion	1E-01
			Inhalation - VOCs	4E-04
			Dermal	1E-01
		Soil	Ingestion	5E-05
		Air	Inhalation - Particulates	1E-07
			Inhalation - VOCs	8E-07
			Total	2E-01
Child	Home	Groundwater	Ingestion	6E-02
			Inhalation - VOCs	2E-04
			Dermal	6E-01
		Soil	Ingestion	4E-05
		Air	Inhalation - Particulates	1E-07
			Inhalation - VOCs	2E-06
			Total	7E-01
Resident South of Landfill - Shallow Groundwater:				
Adult	Home	Groundwater	Ingestion	4E-03
			Inhalation - VOCs	6E-05
			Dermal	1E-04
		Soil	Ingestion	6E-04
			Total	5E-03
Child	Home	Groundwater	Ingestion	2E-03
			Inhalation - VOCs	4E-05
			Dermal	1E-03
		Soil	Ingestion	4E-04
			Total	3E-03
Resident South of Landfill - Deep Groundwater:				
Adult	Home	Groundwater	Ingestion	4E-03
			Inhalation - VOCs	6E-05
			Dermal	1E-04
		Soil	Ingestion	6E-04
			Total	5E-03
Child	Home	Groundwater	Ingestion	2E-03
			Inhalation - VOCs	3E-05
			Dermal	1E-03
		Soil	Ingestion	4E-04
			Total	3E-03

TABLE 7-5 SUMMARY OF ESTIMATED CARCINOGENIC RISK - HYPOTHETICAL FUTURE COMMERCIAL OR AGRICULTURAL USES

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Total Excess Cancer Risk
Plant Worker	Landfill	Groundwater	Ingestion	4E-02
		Soil	Ingestion	6E-06
		Air	Inhalation - Particulates	4E-08
			Inhalation - VOCs	2E-07
			Total	4E-02
Plant Worker	South of Landfill	Groundwater	Ingestion	1E-03
		Soil	Ingestion	6E-05
			Total	1E-03
Agricultural Worker	Landfill	Groundwater	Ingestion	3E-03
		Soil	Ingestion	4E-06
		Air	Inhalation - Particulates	5E-05
			Inhalation - VOCs	2E-09
			Total	3E-03
Downwind off-site resident:				
Adult	Home	Air	Inhalation - Particulates	1E-06
			- Volatiles	8E-07
			Total	2E-06
Child	Home	Air	Inhalation - Particulates	1E-06
			- Volatiles	2E-06
			Total	3E-06

individual and segregate by effect. Values for subchronic (HI_S) exposures were calculated for all child populations and chronic (HI_C) exposures were calculated for all adult populations. Because of the uncertainty inherent in these calculations, all values are reported to only one significant figure. The results are summarized in Tables 7-6 through 7-8.

No HIs for current populations exceed 1E+00. For hypothetical future populations, HIs are greater than 1E+00 for all populations (except the plant worker south of the landfill), which are assumed to utilize groundwater as drinking water. The calculated HI values range from 5E+00 (adult resident south of the landfill) to 1E+03 (child resident on the landfill). The chemicals contributing to this risk include antimony, arsenic, barium, beryllium, cadmium, chromium, mercury, vanadium, cyanide and nitrate/nitrite. For the hypothetical future agricultural worker, tilling operations on the landfill might result in a HI of 4E+00 (due to inhaled chromium).

Risks from Lead Exposure

Since there are no EPA-approved RfD values for lead, it is not possible to evaluate potential noncancer risks of lead by calculation of a HI. An alternative approach is to estimate the likely effect of lead exposure on the concentration of lead in the blood (PbB). Several mathematical models have been developed for calculating the value of PbB as a function of environmental concentrations of lead. Of these, the Uptake/Biokinetic (UBK) model has the greatest flexibility and has been most thoroughly validated.

It is commonly agreed that young children are more susceptible to the effects of lead than older children or adults, since (1) young children tend to have higher exposure levels (especially to soil), (2) young children have higher lead absorption rates, and (3) the nervous system of infants and young children is more sensitive to the neurological effects of lead. The LEAD5 program was used to evaluate the effects of lead in environmental media on children at the Himco Dump site. It should be noted that these calculations include lead exposure from all sources (including food and area-wide emissions to air), and not just those specifically derived from the site (soil, water and/or air). Site-specific lead concentrations were used when available, although most input parameters (e.g., body weight, water intake, soil intake, breathing rate and lead intake from the diet) were taken to be the national average values suggested as defaults by the USEPA. The concentration of lead in air was taken to be the default value except for those downwind populations exposed to episodic site emissions, in which case, calculated concentrations from the site were added to the default value.

Although there is no universally agreed upon value of PbB that may be identified as "safe" for the effects of lead on children, the USEPA had identified 10 µg/dL as the level of concern for health effects in children that warrant avoidance. The geometric blood lead values predicated for this site range from 3 to 100 µg/dL. On this basis, it appears that lead in groundwater is a cause for concern at this site.

TABLE 7-6 SUMMARY OF NONCARCINOGENIC RISK - CURRENT POPULATIONS

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Hazard Index Subchronic	Hazard Index Chronic
Dirt-bike Rider	Site	Soil	Ingestion	--[a]	7E-03
		Air	Inhalation - Particulates	--	2E-01
			Inhalation - VOCs	--	3E-05
			Total	--	2E-01
Wader	Quarry Pit	Surface Water	Ingestion	5E-04	--
			Dermal	4E-04	--
		Sediment	Ingestion	1E-03	--
			Total	2E-03	--
Wader	Ponds	Surface Water	Ingestion	3E-04	--
			Dermal	5E-04	--
		Sediment	Ingestion	2E-04	--
			Total	1E-03	--
Downwind off-site resident:					
Adult	Home	Air	Inhalation - Particulates	--	1E-01
			- Volatiles	--	1E-03
			Total	--	1E-01
Child	Home	Air	Inhalation - Particulates	6E-02	--
			- Volatiles	1E-02	--
			Total	7E-02	--

(a) Exposure not evaluated for this population.

TABLE 7-7 SUMMARY OF NONCARCINOGENIC RISK - HYPOTHETICAL FUTURE RESIDENTIAL POPULATIONS

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Hazard Index[a]
Resident On Landfill:				
Adult	Home	Groundwater	Ingestion	5E+02
			Inhalation - VOCs	2E+00
			Dermal	2E+01
		Soil	Ingestion	2E-01
		Air	Inhalation - Particulates	1E-02
			Inhalation - VOCs	1E-03
			Total	5E+02
Child	Home	Groundwater	Ingestion	9E+02
			Inhalation - VOCs	4E+00
			Dermal	1E+02
		Soil	Ingestion	8E-01
		Air	Inhalation - Particulates	7E-03
			Inhalation - VOCs	1E-02
			Total	1E+03
Resident South of Landfill - Shallow Groundwater:				
Adult	Home	Groundwater	Ingestion	9E+00
			Inhalation - VOCs	2E-01
			Dermal	8E-01
		Soil	Ingestion	1E-01
			Total	1E+01
Child	Home	Groundwater	Ingestion	2E+01
			Inhalation - VOCs	2E-01
			Dermal	3E+00
		Soil	Ingestion	5E-01
			Total	2E+01
Resident South of Landfill - Deep Groundwater:				
Adult	Home	Groundwater	Ingestion	4E+00
			Inhalation - VOCs	2E-01
			Dermal	9E-01
		Soil	Ingestion	1E-01
			Total	5E+00
Child	Home	Groundwater	Ingestion	9E+00
			Inhalation - VOCs	2E-01
			Dermal	4E+00
		Soil	Ingestion	5E-01
			Total	1E+01

(a) Hazard index is subchronic for child populations and chronic for all others.

TABLE 7-8 SUMMARY OF ESTIMATED NONCARCINOGENIC RISK - HYPOTHETICAL FUTURE COMMERCIAL OR AGRICULTURAL POPULATIONS

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Hazard Index[a]
Plant Worker	Landfill	Groundwater	Ingestion	1E+02
		Soil	Ingestion	3E-02
		Air	Inhalation - Particulates	3E-03
			Inhalation - VOCs	3E-04
			Total	1E+02
Plant Worker	South of Landfill	Groundwater	Ingestion	1E+00
		Soil	Ingestion	2E-02
			Total	1E+00
Agricultural Worker	Plant	Groundwater	Ingestion	1E+01
		Soil	Ingestion	2E-02
		Air	Inhalation - Particulates	4E+00
			Inhalation - Volatiles	4E-06
			Total	1E+01
Downwind off-site resident:				
Adult	Home	Air	Inhalation - Particulates	1E-01
			- Volatiles	1E-03
			Total	1E-01
Child	Home	Air	Inhalation - Particulates	5E-02
			- Volatiles	1E-02
			Total	6E-02

(a) Hazard index is subchronic for child populations and chronic for all others.

Summary

The greatest cause for health concern at the Himco site is the hypothetical future use of groundwater below the landfill. Risks from ingestion, dermal contact and inhalation of volatiles from this groundwater present carcinogenic risks in the range of 1E-01 (although a significant portion of this risk is due to undetected beryllium, assumed to be present). Hazard index values for these pathways are approximately 500 to 1,000. Further downgradient of the landfill (south), the estimated excess cancer risks to a future resident are approximately 5E-3. Virtually all this risk, however, is attributable either to chemicals not detected, but conservatively evaluated as if they were present, or to chemicals attributable to upgradient or background sources. It therefore appears that although groundwater beneath the landfill is contaminated, this contamination has not moved (or at least has not been detected) at downgradient exposure points south of the landfill.

In addition to groundwater, there is an estimated excess cancer risk of 4 to 6E-04 to a future resident living south of the landfill where PAHs were detected in the soil. If the site were to revert to an agricultural use, there could be cause for concern via tilling due to chromium present in the landfill soil at a level (4.7 mg/kg) below that detected in background (7.1 mg/kg).

Other future land uses which do not involve groundwater and current uses of the site do not present excess cancer risks greater than 1E-04 or hazard indices greater than 1E+00.

7.4 Uncertainties

There are many aspects of the risk assessment process where precise evaluations are not possible. These include uncertainties related to estimating levels of contaminants in environmental media, using mathematical models, evaluating the amount of contaminants taken in by humans and predicting the likelihood of adverse health effects.

- The evaluation of human health risks assumed that surface soil, groundwater, surface water and sediment would remain as contaminated in the future as they are at present. This assumption probably results in an overestimate of risk, because some decrease in concentration is probable for the contaminants of potential concern through natural fate and transport processes.

- The determination of the appropriate exposure factors to be used in calculating daily intakes can be uncertain. Standardized exposure factors were used where possible. A few exposure factors were used based on site-specific information. Highly uncertain exposure factors were selected for the recreational populations and the hypothetical future agricultural population. Overall, exposure estimates were intended to be conservative and so could contribute to an overestimate of risk.

- The estimation of air concentrations of particulates and volatiles were made with mathematical models utilizing uncertain input variables. It is not known if this under- or overestimates risk.

- Toxicity values were not available for all combinations of chemicals, durations, routes and endpoints. The absence of these values is likely to result in an underestimate of noncancer and cancer health risks at the site.

- Toxicity values that were used were derived using conservative procedures, particularly for cancer risk, and thus may tend to overestimate risk to the average person.

In summary, most assumptions and professional judgments were intentionally conservative, and thus, likely to overestimate potential exposure or risk. Consequently, the risks estimated for this site should be considered approximate and are more likely to be higher than lower than the true risk.

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APPENDIX 1

SUMMARY OF SITE MONITORING DATA

TABLE A1-1 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN SOILS AND GROUNDWATER

CLASS	CHEMICAL	SOIL SAMPLES: FREQ. OF DETECTION Hits	Total	RANGE OF DETECTED VALUES (mg/kg) Min	Max	RANGE OF NON-DETECTED VALUES (mg/kg) Min	Max	GROUNDWATER SAMPLES: FREQ. OF DETECTION Hits	Total	RANGE OF DETECTED VALUES (mg/L) Min	Max	RANGE OF NON-DETECTED VALUES (mg/L) Min	Max
VOLATILES	1,1,1-Trichloroethane	0	56			3.0E-03	4.0E-02	3	39	1.0E-03	8.0E-03	2.5E-03	1.0E-02
	1,1,2,2-Tetrachloroethane	0	56			3.0E-03	4.0E-02	0	39			2.5E-03	1.0E-02
	1,1,2-Trichloroethane	0	56			3.0E-03	4.0E-02	0	39			2.5E-03	1.0E-02
	1,1-Dichloroethane	0	56			3.0E-03	4.0E-02	3	39	3.0E-03	3.0E-03	2.5E-03	1.0E-02
	1,1-Dichloroethene	1	56	5.0E-03	5.0E-03	3.0E-03	4.0E-02	0	39			2.5E-03	1.0E-02
	1,2-Dichloroethane	0	56			3.0E-03	4.0E-02	0	39			2.5E-03	1.0E-02
	1,2-Dichloroethene(total)	0	56			3.0E-03	4.0E-02	4	39	5.0E-03	6.0E-03	2.5E-03	1.0E-02
	1,2-Dichloropropane	0	56			3.0E-03	4.0E-02	0	39			2.5E-03	1.0E-02
	2-Butanone	7	46	2.0E-03	2.1E-02	5.0E-03	3.2E-02	0	39			5.0E-03	1.0E-02
	2-Hexanone	0	56			5.0E-03	4.0E-02	2	39	7.0E-04	7.0E-04	5.0E-03	1.0E-02
	4-Methyl-2-pentanone	0	56			5.0E-03	4.0E-02	0	39			5.0E-03	1.0E-02
	Acetone	18	56	8.0E-03	1.4E-01	5.0E-03	2.8E-02	4	39	9.0E-03	2.7E-01	1.0E-03	1.7E-02
	Benzene	1	56	2.5E-02	2.5E-02	3.0E-03	1.3E-02	5	39	1.0E-03	3.0E-03	2.5E-03	1.0E-02
	Bromodichloromethane	0	56			3.0E-03	4.0E-02	1	39	7.0E-04	7.0E-04	2.5E-03	1.0E-02
	Bromoform	0	56			3.0E-03	4.0E-02	0	39			2.5E-03	1.0E-02
	Bromomethane	0	56			5.0E-03	4.0E-02	0	28			5.0E-03	1.0E-02
	Carbon Disulfide	2	56	1.9E-03	4.0E-03	3.0E-03	8.0E-02	1	39	1.0E-03	1.0E-03	2.5E-03	1.0E-02
	Carbon Tetrachloride	0	56			3.0E-03	4.0E-02	0	39			2.5E-03	1.0E-02
	Chlorobenzene	0	56			3.0E-03	4.0E-02	1	39	1.7E-03	1.7E-03	2.5E-03	1.0E-02
	Chloroethane	0	56			5.0E-03	4.0E-02	3	39	2.0E-03	1.5E-02	5.0E-03	1.0E-02
	Chloroform	0	56			3.0E-03	4.0E-02	3	39	1.8E-03	6.0E-03	1.0E-03	1.0E-02
	Chloromethane	0	56			5.0E-03	4.0E-02	0	28			5.0E-03	1.0E-02
	cis-1,3-Dichloropropene	0	56			3.0E-03	4.0E-02	0	39			2.5E-03	1.0E-02
	Dibromochloromethane	0	56			3.0E-03	4.0E-02	0	39			2.5E-03	1.0E-02
	Ethyl Benzene	3	56	7.0E-04	8.1E-02	3.0E-03	1.3E-02	0	39			2.5E-03	1.0E-02
	Methylene Chloride	12	56	3.0E-03	1.6E-02	3.5E-03	4.0E-02	7	39	1.0E-03	3.0E-03	5.0E-03	1.0E-02
	Styrene	1	56	8.0E-04	8.0E-04	3.0E-03	4.0E-02	0	39			2.5E-03	1.0E-02
	Tetrachloroethene	1	56	6.0E-03	6.0E-03	3.0E-03	4.0E-02	0	39			2.5E-03	1.0E-02
	Toluene	21	56	1.0E-03	3.1E-02	3.0E-03	2.0E-02	0	39			2.5E-03	1.0E-02
	trans-1,3-Dichloropropene	0	56			3.0E-03	4.0E-02	0	39			2.5E-03	1.0E-02
	Trichloroethene	2	56	9.0E-04	4.0E-03	3.0E-03	4.0E-02	3	39	6.0E-04	4.2E-02	2.5E-03	1.0E-02
	Vinyl Acetate	0	39			5.8E-03	1.8E-02	0	26			5.0E-03	1.0E-02
	Vinyl Chloride	0	56			5.0E-03	4.0E-02	0	28			5.0E-03	1.0E-02
	Xylenes (Total)	5	56	7.0E-04	1.1E-01	3.0E-03	1.3E-02	0	39			2.5E-03	1.0E-02
SEMIVOLATILES	1,2,4-Trichlorobenzene	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	1,2-Dichlorobenzene	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	1,3-Dichlorobenzene	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	1,4-Dichlorobenzene	6	54	1.0E-01	2.1E-01	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	2,4,5-Trichlorophenol	0	54			4.1E-01	5.2E+00	0	39			1.3E-02	5.4E-02
	2,4,6-Trichlorophenol	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	2,4-Dichlorophenol	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	2,4-Dimethylphenol	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	2,4-Dinitrophenol	0	54			4.1E-01	5.2E+00	0	39			1.3E-02	5.4E-02
	2,4-Dinitrotoluene	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	2,6-Dinitrotoluene	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	2-Chloronaphthalene	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	2-Chlorophenol	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	2-Methylnaphthalene	1	54	1.8E-02	1.8E-02	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	2-Methylphenol	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02

TABLE A1-1 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN SOILS AND GROUNDWATER

		SOIL SAMPLES						GROUNDWATER SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	2-Nitroaniline	0	54			4.1E-01	5.2E+00	0	39			1.3E-02	5.4E-02
	2-Nitrophenol	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	3,3-Dichlorobenzidine	0	54			1.7E-01	2.2E+00	0	39			5.0E-03	2.2E-02
	3-Nitroaniline	0	54			4.1E-01	5.2E+00	0	39			1.3E-02	5.4E-02
	4,6-Dinitro-2-methylphenol	0	54			4.1E-01	5.2E+00	0	39			1.3E-02	5.4E-02
	4-Bromophenyl-phenylether	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	4-Chloro-3-methylphenol	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	4-Chloroaniline	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	4-Chlorophenyl-phenyl ether	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	4-Methylphenol	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	4-Nitroaniline	0	54			4.1E-01	5.2E+00	0	39			1.3E-02	5.4E-02
	4-Nitrophenol	0	54			4.1E-01	5.2E+00	0	39			1.3E-02	5.4E-02
	Acenaphthene	4	55	5.9E-02	8.3E-01	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Acenaphthylene	2	56	5.2E+00	7.7E+00	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Anthracene	5	56	8.2E-02	4.2E+00	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Benzo(a)anthracene	8	56	2.3E-02	1.3E+01	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Benzo(a)pyrene	8	56	1.2E-01	7.6E+00	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Benzo(b)fluoranthene	9	56	5.8E-02	2.6E+01	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Benzo(g,h,i)perylene	5	54	2.5E-01	3.5E+00	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Benzo(k)fluoranthene	9	56	7.3E-02	1.5E+01	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Benzoic acid	1	39	7.5E-02	7.5E-02	9.5E-01	5.2E+00	0	26			2.5E-02	5.4E-02
	Benzyl alcohol	0	39			2.0E-01	1.1E+00	0	26			5.0E-03	1.1E-02
	bis(2-Chloroethoxy) methane	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	bis(2-Chloroethyl) ether	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	bis(2-Chloroisopropyl) ether	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	bis(2-Ethylhexyl)phthalate	32	54	1.8E-02	7.8E+00	1.7E-01	1.1E+00	10	39	2.0E-03	1.1E-01	5.0E-03	1.1E-02
	Butylbenzylphthalate	1	54	2.4E-01	2.4E-01	1.7E-01	1.1E+00	1	39	1.1E-02	1.1E-02	5.0E-03	1.1E-02
	Carbazole	3	17	3.6E-02	9.0E-01	1.7E-01	3.9E-01	0	12			5.0E-03	1.0E-02
	Chrysene	9	56	1.3E-01	1.9E+01	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Di-n-butylphthalate	10	56	8.6E-02	4.9E-01	1.7E-01	9.5E+00	0	39			5.0E-03	1.1E-02
	Di-n-octylphthalate	1	54	1.4E-01	1.4E-01	1.7E-01	1.1E+00	1	39	6.5E-03	6.5E-03	5.0E-03	1.1E-02
	Dibenzo(a,h)anthracene	4	56	9.4E-02	2.2E+00	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Dibenzofuran	3	56	2.3E-02	1.7E+00	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Diethylphthalate	0	54			1.7E-01	1.1E+00	3	39	2.0E-03	3.6E-02	5.0E-03	1.1E-02
	Dimethylphthalate	1	54	4.2E-02	4.2E-02	1.7E-01	1.1E+00	1	39	7.0E-03	7.0E-03	5.0E-03	1.1E-02
	Fluoranthene	10	56	1.7E-02	3.3E+01	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Fluorene	4	56	4.3E-02	1.6E+00	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Hexachlorobenzene	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Hexachlorobutadiene	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Hexachlorocyclopentadiene	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Hexachloroethane	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Indeno(1,2,3-cd)pyrene	7	56	2.3E-01	4.2E+00	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Isophorone	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	N-Nitrosodinpropylamine	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	N-nitrosodiphenylamine	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Naphthalene	2	55	1.8E-02	4.0E+00	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Nitrobenzene	0	54			1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Pentachlorophenol	0	54			4.1E-01	5.2E+00	0	39			1.3E-02	5.4E-02
	Phenanthrene	8	56	4.2E-02	1.2E+01	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
	Phenol	0	54			1.7E-01	1.1E+00	1	39	2.0E-03	2.0E-03	5.0E-03	1.1E-02

TABLE A1-1 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN SOILS AND GROUNDWATER

		SOIL SAMPLES						GROUNDWATER SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	Pyrene	10	56	3.5E-02	1.5E+01	1.7E-01	1.1E+00	0	39			5.0E-03	1.1E-02
PESTICIDES	4,4-DDD	0	56			1.7E-03	5.2E-02	0	38			5.0E-05	1.1E-04
	4,4-DDE	1	56	4.1E-03	4.1E-03	1.7E-03	5.2E-02	0	38			5.0E-05	1.0E-03
	4,4-DDT	2	56	1.2E-02	6.4E-02	1.7E-03	5.2E-02	0	38			5.0E-05	1.1E-04
	Aldrin	0	56			9.0E-04	2.6E-02	0	38			2.5E-05	5.3E-05
	alpha-BHC	0	56			9.0E-04	2.6E-02	0	38			2.5E-05	5.3E-05
	alpha-Chlordane	0	56			9.0E-04	2.6E-01	0	38			2.5E-05	5.3E-04
	Aroclor-1016	0	56			1.7E-02	3.5E-01	0	38			2.5E-04	1.0E-03
	Aroclor-1221	0	56			3.5E-02	7.2E-01	0	38			2.5E-04	2.0E-03
	Aroclor-1232	0	56			1.7E-02	3.5E-01	0	38			2.5E-04	1.0E-03
	Aroclor-1242	0	56			1.7E-02	3.5E-01	0	38			2.5E-04	1.0E-03
	Aroclor-1248	0	56			1.7E-02	3.5E-01	0	38			2.5E-04	1.0E-03
	Aroclor-1254	0	56			1.7E-02	5.2E-01	0	38			5.0E-04	1.1E-03
	Aroclor-1260	0	56			1.7E-02	5.2E-01	0	38			5.0E-04	1.1E-03
	beta-BHC	0	56			9.0E-04	2.6E-02	0	38			2.5E-05	5.3E-05
	delta-BHC	0	56			9.0E-04	2.6E-02	0	38			2.5E-05	5.3E-05
	Dieldrin	0	56			1.7E-03	5.2E-02	0	38			5.0E-05	1.0E-03
	Endosulfan I	0	56			9.0E-04	2.6E-02	0	38			2.5E-05	5.0E-04
	Endosulfan II	0	56			1.7E-03	5.2E-02	0	38			5.0E-05	1.1E-04
	Endosulfan sulfate	0	56			1.7E-03	5.2E-02	0	38			5.0E-05	1.1E-04
	Endrin	0	56			1.7E-03	5.2E-02	0	38			5.0E-05	1.0E-03
	Endrin aldehyde	0	17			1.7E-03	3.5E-02	0	13			5.0E-05	1.0E-04
	Endrin ketone	0	56			1.7E-03	5.2E-02	0	38			5.0E-05	1.1E-04
	gamma-BHC (lindane)	0	56			9.0E-04	2.6E-02	0	38			2.5E-05	5.3E-05
	gamma-Chlordane	0	56			9.0E-04	2.6E-01	0	38			2.5E-05	5.3E-04
	Heptachlor	0	56			9.0E-04	2.6E-02	0	38			2.5E-05	5.3E-05
	Heptachlor epoxide	0	56			9.0E-04	2.6E-02	0	38			2.5E-05	5.0E-04
	Methoxychlor	0	56			9.0E-03	2.6E-01	0	38			2.5E-04	5.3E-04
	Toxaphene	0	56			9.0E-02	1.8E+00	0	38			5.0E-04	5.0E-03
INORGANICS	Aluminum, Dissolved							14	38	1.8E-02	1.2E+00	1.8E-02	8.8E-02
	Aluminum, Total	52	56	9.7E+00	6.8E+03	9.0E+00	1.0E+01	29	38	2.9E-02	1.1E+02	1.8E-02	9.1E-02
	Antimony, Dissolved							9	38	2.3E-02	6.0E-02	6.5E-03	3.7E-02
	Antimony, Total	25	56	1.5E+00	4.7E+01	1.9E+00	1.2E+01	10	38	3.2E-02	6.3E-02	6.5E-03	3.7E-02
	Arsenic, Dissolved							18	38	1.7E-03	1.6E-02	5.0E-04	3.0E-03
	Arsenic, Total	43	56	4.7E-01	1.3E+01	1.6E-01	9.8E-01	21	38	1.0E-03	5.5E-02	5.0E-04	3.0E-03
	Barium, Dissolved							36	38	7.4E-03	5.1E-01	4.3E-03	2.2E-02
	Barium, Total	47	56	1.3E+00	1.0E+02	2.6E+00	7.3E+00	37	38	8.2E-03	5.1E-01	2.2E-02	2.2E-02
	Beryllium, Dissolved							3	38	2.8E-03	1.3E-02	5.0E-04	3.0E-03
	Beryllium, Total	28	56	2.0E-01	9.1E-01	1.1E-01	3.3E-01	6	38	1.2E-03	5.4E-03	5.0E-04	3.0E-03
	Cadmium, Dissolved							1	38	7.0E-03	7.0E-03	5.0E-04	5.0E-03
	Cadmium, Total	1	56	1.1E+00	1.1E+00	2.1E-01	1.6E+00	4	38	1.3E-03	3.0E-03	5.0E-04	5.0E-03
	Calcium, Dissolved							38	38	1.4E+01	2.2E+02		
	Calcium, Total	56	56	2.5E+02	3.0E+05			38	38	1.6E+01	3.6E+02		
	Chromium, Dissolved							6	38	2.1E-03	2.1E-01	1.0E-03	6.0E-03
	Chromium, Total	44	56	1.1E+00	1.6E+01	7.5E-01	2.2E+00	15	38	1.6E-03	3.5E-01	2.0E-03	6.0E-03
	Cobalt, Dissolved							5	38	3.0E-03	1.7E-02	1.5E-03	1.6E-02
	Cobalt, Total	41	56	1.3E+00	5.7E+00	9.5E-01	2.3E+00	11	38	3.1E-03	2.9E-02	1.5E-03	1.2E-02
	Copper, Dissolved							7	38	3.5E-03	1.7E-02	1.5E-03	6.0E-03

TABLE A1-1 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN SOILS AND GROUNDWATER

		SOIL SAMPLES						GROUNDWATER SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	Copper, Total	51	56	1.3E+00	2.3E+02	9.6E-01	1.7E+00	21	38	3.7E-03	1.4E-01	2.0E-03	6.0E-03
	Iron, Dissolved							28	38	6.2E-02	2.5E+01	5.0E-03	4.5E-02
	Iron, Total	55	56	9.8E+00	1.3E+04	4.5E+00	4.5E+00	37	38	1.2E-01	7.9E+01	8.4E-02	8.4E-02
	Lead, Dissolved							15	34	1.1E-03	7.3E-03	5.0E-04	2.0E-02
	Lead, Total	51	56	5.0E-01	2.5E+02	3.1E-01	1.6E+00	18	36	1.1E-03	2.1E-01	5.0E-04	2.0E-02
	Magnesium, Dissolved							38	38	3.0E+00	4.2E+01		
	Magnesium, Total	51	56	1.5E+01	2.4E+04	1.8E+02	2.0E+02	38	38	3.5E+00	7.8E+01		
	Manganese, Dissolved							36	38	4.2E-03	2.7E+00	1.0E-03	1.3E-03
	Manganese, Total	54	56	1.3E+00	5.6E+02	1.2E+00	1.3E+00	38	38	8.5E-03	3.6E+00		
	Mercury, Dissolved							2	38	2.0E-04	2.0E-04	1.0E-04	2.0E-04
	Mercury, Total	6	56	1.3E-01	5.4E-01	4.0E-02	1.7E-01	4	38	2.0E-04	6.0E-04	1.0E-04	2.0E-04
	Nickel, Dissolved							2	38	1.1E-02	7.9E-02	3.0E-03	2.5E-02
	Nickel, Total	36	56	2.4E+00	2.2E+01	2.9E+00	9.1E+00	9	38	7.1E-03	1.1E-01	3.0E-03	2.5E-02
	Potassium, Dissolved							35	38	4.8E-01	2.9E+01	6.1E-01	1.6E+00
	Potassium, Total	36	56	8.7E+01	6.8E+02	5.4E+01	2.5E+02	32	38	5.8E-01	2.9E+01	3.8E-01	1.8E+00
	Selenium, Dissolved							4	38	2.1E-03	3.9E-03	2.0E-03	4.0E-03
	Selenium, Total	12	56	2.3E-01	1.4E+00	1.2E-01	4.9E+00	9	38	2.0E-03	3.3E-02	1.0E-03	4.0E-03
	Silver, Dissolved							5	38	8.8E-03	1.1E-02	1.0E-03	1.0E-02
	Silver, Total	5	50	3.6E-01	2.8E+00	3.5E-01	1.3E+00	8	38	6.9E-03	1.8E-02	1.0E-03	9.2E-03
	Sodium, Dissolved							38	38	1.9E+00	9.1E+01		
	Sodium, Total	30	56	2.1E+01	9.9E+01	1.7E+01	1.8E+02	38	38	2.0E+00	9.1E+01		
	Thallium, Dissolved							0	38			1.5E-03	5.0E-03
	Thallium, Total	0	54			1.0E-01	3.3E+00	0	38			1.0E-03	1.0E-02
	Vanadium, Dissolved							11	38	4.5E-03	1.3E-02	1.0E-03	1.5E-02
	Vanadium, Total	49	56	1.5E+00	1.9E+01	6.3E-01	3.0E+00	13	38	4.7E-03	1.1E-01	1.0E-03	1.2E-02
	Zinc, Dissolved							18	38	6.1E-03	1.4E+00	3.0E-03	1.4E-02
	Zinc, Total	45	56	1.7E+00	2.8E+02	3.1E-01	2.6E+00	23	38	6.8E-03	1.4E+01	3.0E-03	1.4E-02
	Cyanide, Total	6	56	1.3E+00	2.4E+01	1.1E-01	6.0E+00	0	30			5.0E-03	4.0E-02
OTHER	Bromide, Dissolved							20	26	7.5E-02	3.5E+00	5.0E-02	1.0E-01
	Chloride, Cl							25	25	2.9E+00	2.6E+02		
	Nitrogen, Ammonia (NH3)							19	26	1.1E-01	3.0E+01	4.0E+01	4.0E+01
	Nitrogen, Nitrate + Nitrite (NO2 + NO3)							3	11	1.4E-01	1.6E+00	2.0E+01	4.0E+01
	Sulfate, SO4							22	25	5.9E+00	8.1E+02	4.5E+01	4.5E+01
	TP (Total Phosphorus)							11	12	9.0E-02	4.0E-01	1.0E+01	1.0E+01

TABLE A1-2 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN SURFACE WATER AND SEDIMENT

		SURFACE WATER SAMPLES						SEDIMENT SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
VOLATILES	1,1,1-Trichloroethane	0	16			2.5E-03	1.0E-02	1	18	1.0E-03	1.0E-03	3.0E-03	3.2E-02
	1,1,2,2-Tetrachloroethane	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	1,1,2-Trichloroethane	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	1,1-Dichloroethane	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	1,1-Dichloroethene	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	1,2-Dichloroethane	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	1,2-Dichloroethene(total)	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	1,2-Dichloropropane	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	2-Butanone	0	11			5.0E-03	1.0E-02	3	18	8.0E-03	2.7E-02	3.8E-03	2.5E-02
	2-Hexanone	0	18			5.0E-03	1.0E-02	0	18			6.0E-03	3.2E-02
	4-Methyl-2-pentanone	1	18	3.0E-03	3.0E-03	5.0E-03	1.0E-02	0	18			6.0E-03	3.2E-02
	Acetone	4	18	3.0E-03	5.0E-03	5.0E-03	1.0E-02	2	18	2.1E-02	4.9E-02	6.0E-03	1.1E-01
	Benzene	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	Bromodichloromethane	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	Bromoform	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	Bromomethane	0	18			5.0E-03	1.0E-02	0	18			6.0E-03	3.2E-02
	Carbon Disulfide	2	18	4.0E-03	4.0E-03	2.5E-03	1.0E-02	2	18	8.5E-03	2.7E-02	3.0E-03	3.2E-02
	Carbon Tetrachloride	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	Chlorobenzene	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	Chloroethane	0	18			5.0E-03	1.0E-02	0	18			6.0E-03	3.2E-02
	Chloroform	0	18			2.5E-03	1.0E-02	1	18	7.0E-04	7.0E-04	3.0E-03	3.2E-02
	Chloromethane	0	18			5.0E-03	1.0E-02	0	18			6.0E-03	3.2E-02
	cis-1,3-Dichloropropene	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	Dibromochloromethane	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	Ethyl Benzene	4	18	1.0E-03	2.3E-03	2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	Methylene Chloride	2	18	6.0E-03	7.5E-02	5.0E-03	6.1E-02	1	18	2.0E-03	2.0E-03	3.0E-03	3.2E-02
	Styrene	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	Tetrachloroethene	0	18			2.5E-03	1.0E-02	1	18	1.0E-03	1.0E-03	3.0E-03	3.2E-02
	Toluene	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	trans-1,3-Dichloropropene	0	18			2.5E-03	1.0E-02	0	18			3.0E-03	3.2E-02
	Trichloroethene	0	18			2.5E-03	1.0E-02	1	18	2.0E-03	2.0E-03	3.8E-03	3.2E-02
	Vinyl Acetate	0	2			5.0E-03	1.0E-02	0	12			6.0E-03	1.7E-02
	Vinyl Chloride	0	18			5.0E-03	1.0E-02	0	18			6.0E-03	3.2E-02
	Xylenes (Total)	5	18	2.0E-03	6.0E-03	2.5E-03	1.0E-02	1	18	1.0E-03	1.0E-03	3.0E-03	3.2E-02
SEMIVOLATILES	1,2,4-Trichlorobenzene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	1,2-Dichlorobenzene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	1,3-Dichlorobenzene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	1,4-Dichlorobenzene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	2,4,5-Trichlorophenol	0	18			1.3E-02	5.0E-02	0	18			4.9E-01	4.3E+00
	2,4,6-Trichlorophenol	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	2,4-Dichlorophenol	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	2,4-Dimethylphenol	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	2,4-Dinitrophenol	0	18			1.3E-02	5.0E-02	0	18			4.9E-01	4.3E+00
	2,4-Dinitrotoluene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	2,6-Dinitrotoluene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	2-Chloronaphthalene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	2-Chlorophenol	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	2-Methylnaphthalene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	2-Methylphenol	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00

TABLE A1-2 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN SURFACE WATER AND SEDIMENT

		SURFACE WATER SAMPLES						SEDIMENT SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	2-Nitroaniline	0	18			1.3E-02	5.0E-02	0	18			4.9E-01	4.3E+00
	2-Nitrophenol	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	3,3-Dichlorobenzidine	0	18			5.0E-03	2.0E-02	0	18			2.0E-01	1.8E+00
	3-Nitroaniline	0	17			1.3E-02	5.0E-02	0	18			4.9E-01	4.3E+00
	4,6-Dinitro-2-methylphenol	0	18			1.3E-02	5.0E-02	0	18			4.9E-01	4.3E+00
	4-Bromophenyl-phenylether	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	4-Chloro-3-methylphenol	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	4-Chloroaniline	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	4-Chlorophenyl-phenyl ether	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	4-Methylphenol	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	4-Nitroaniline	0	17			1.3E-02	5.0E-02	0	18			4.9E-01	4.3E+00
	4-Nitrophenol	0	18			1.3E-02	5.0E-02	0	18			4.9E-01	4.3E+00
	Acenaphthene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Acenaphthylene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Anthracene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Benzo(a)anthracene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Benzo(a)pyrene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Benzo(b)fluoranthene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Benzo(g,h,i)perylene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Benzo(k)fluoranthene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Benzoic acid	0	12			2.5E-02	5.0E-02	2	12	9.3E-02	1.9E-01	9.8E-01	4.3E+00
	Benzyl alcohol	0	12			5.0E-03	1.0E-02	0	12			2.0E-01	8.8E-01
	bis(2-Chloroethoxy) methane	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	bis(2-Chloroethyl) ether	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	bis(2-Chloroisopropyl) ether	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	bis(2-Ethylhexyl)phthalate	0	18			5.0E-03	1.0E-02	8	18	4.6E-02	5.4E-01	2.0E-01	8.8E-01
	Butylbenzylphthalate	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Carbazole	0	6			5.0E-03	1.0E-02	0	6			2.0E-01	1.1E+00
	Chrysene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Di-n-butylphthalate	0	18			5.0E-03	1.0E-02	1	18	7.6E-02	7.6E-02	2.0E-01	1.1E+00
	Di-n-octylphthalate	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Dibenzo(a,h)anthracene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Dibenzofuran	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Diethylphthalate	0	18			5.0E-03	1.0E-02	1	18	2.3E-01	2.3E-01	2.0E-01	1.1E+00
	Dimethylphthalate	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Fluoranthene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Fluorene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Hexachlorobenzene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Hexachlorobutadiene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Hexachlorocyclopentadiene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Hexachloroethane	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Indeno(1,2,3-cd)pyrene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Isophorone	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	N-Nitrosodinpropylamine	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	N-nitrosodiphenylamine	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Naphthalene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Nitrobenzene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Pentachlorophenol	0	18			1.3E-02	5.0E-02	0	18			4.9E-01	4.3E+00
	Phenanthrene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
	Phenol	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00

TABLE A1-2 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN SURFACE WATER AND SEDIMENT

		SURFACE WATER SAMPLES						SEDIMENT SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	Pyrene	0	18			5.0E-03	1.0E-02	0	18			2.0E-01	1.1E+00
PESTICIDES	4,4-DDD	0	15			5.0E-05	1.0E-04	0	18			2.0E-03	4.3E-02
	4,4-DDE	0	15			5.0E-05	1.0E-04	0	18			2.0E-03	4.3E-02
	4,4-DDT	0	15			5.0E-05	1.0E-04	0	18			2.0E-03	4.3E-02
	Aldrin	0	15			2.5E-05	5.0E-05	0	18			1.1E-03	2.1E-02
	alpha-BHC	0	15			2.5E-05	5.0E-05	0	18			1.1E-03	2.1E-02
	alpha-Chlordane	0	15			2.5E-05	5.0E-04	0	18			1.1E-03	2.1E-01
	Aroclor-1016	0	15			2.5E-04	1.0E-03	0	18			2.0E-02	2.1E-01
	Aroclor-1221	0	15			2.5E-04	2.0E-03	0	18			4.1E-02	2.2E-01
	Aroclor-1232	0	15			2.5E-04	1.0E-03	0	18			2.0E-02	2.1E-01
	Aroclor-1242	0	15			2.5E-04	1.0E-03	0	18			2.0E-02	2.1E-01
	Aroclor-1248	0	15			2.5E-04	1.0E-03	1	18	9.5E-02	9.5E-02	2.0E-02	2.1E-01
	Aroclor-1254	0	15			5.0E-04	1.0E-03	0	18			2.0E-02	4.3E-01
	Aroclor-1260	0	15			5.0E-04	1.0E-03	0	18			2.0E-02	4.3E-01
	beta-BHC	0	15			2.5E-05	5.0E-05	0	18			1.1E-03	2.1E-02
	delta-BHC	0	15			2.5E-05	5.0E-05	0	18			1.1E-03	2.1E-02
	Dieldrin	0	15			5.0E-05	1.0E-04	0	18			2.0E-03	4.3E-02
	Endosulfan I	0	15			2.5E-05	5.0E-05	0	18			1.1E-03	2.1E-02
	Endosulfan II	0	15			5.0E-05	1.0E-04	0	18			2.0E-03	4.3E-02
	Endosulfan sulfate	0	15			5.0E-05	1.0E-04	0	18			2.0E-03	4.3E-02
	Endrin	0	15			5.0E-05	1.0E-04	0	18			2.0E-03	4.3E-02
	Endrin aldehyde	0	6			5.0E-05	1.0E-04	0	6			2.0E-03	1.1E-02
	Endrin ketone	0	15			5.0E-05	1.0E-04	0	18			2.0E-03	4.3E-02
	gamma-BHC (lindane)	0	15			2.5E-05	5.0E-05	0	18			1.1E-03	2.1E-02
	gamma-Chlordane	0	15			2.5E-05	5.0E-04	0	18			1.1E-03	2.1E-01
	Heptachlor	0	15			2.5E-05	5.0E-05	0	18			1.1E-03	2.1E-02
	Heptachlor epoxide	0	15			2.5E-05	5.0E-05	0	18			1.1E-03	2.1E-02
	Methoxychlor	0	15			2.5E-04	5.0E-04	0	18			1.1E-02	2.1E-01
	Toxaphene	0	15			5.0E-04	5.0E-03	0	18			9.8E-02	5.5E-01
INORGANICS	Aluminum, Dissolved	6	6	2.2E-02	4.2E-02								
	Aluminum, Total	18	18	3.1E-02	4.8E-01			18	18	9.6E+02	1.8E+04		
	Antimony, Dissolved	0	6			7.0E-03	1.4E-02						
	Antimony, Total	0	18			1.2E-02	4.7E-02	1	18	3.0E+01	3.0E+01	3.2E+00	2.7E+01
	Arsenic, Dissolved	1	6	4.5E-03	4.5E-03	2.0E-03	2.0E-03						
	Arsenic, Total	8	18	1.8E-03	4.7E-03	2.0E-03	2.0E-03	18	18	9.0E-01	2.2E+01		
	Barium, Dissolved	6	6	2.8E-02	5.6E-02								
	Barium, Total	18	18	2.9E-02	6.2E-02			18	18	3.9E+00	1.3E+02		
	Beryllium, Dissolved	0	6			5.0E-04	1.0E-03						
	Beryllium, Total	0	18			5.0E-04	1.0E-03	6	18	3.9E-01	1.2E+00	1.1E-01	2.8E-01
	Cadmium, Dissolved	1	6	8.0E-04	8.0E-04	1.0E-03	1.0E-03						
	Cadmium, Total	0	18			1.5E-03	3.0E-03	0	18			3.2E-01	1.7E+00
	Calcium, Dissolved	6	6	5.2E+01	7.4E+01								
	Calcium, Total	18	18	5.1E+01	7.8E+01			18	18	2.1E+02	1.2E+05		
	Chromium, Dissolved	0	6			1.0E-03	2.0E-03						
	Chromium, Total	2	18	6.1E-03	2.9E-02	3.0E-03	6.0E-03	18	18	1.7E+00	2.1E+01		
	Cobalt, Dissolved	0	6			1.0E-03	2.0E-03						
	Cobalt, Total	0	18			2.0E-03	8.0E-03	15	18	2.0E+00	2.0E+01	7.5E-01	1.6E+00
	Copper, Dissolved	0	6			1.0E-03	2.0E-03						

TABLE A1-2 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN SURFACE WATER AND SEDIMENT

		SURFACE WATER SAMPLES						SEDIMENT SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	Copper, Total	1	18	4.1E-03	4.1E-03	1.5E-03	5.0E-03	18	18	1.4E+00	4.4E+01		
	Iron, Dissolved	6	6	7.4E-03	2.1E-01								
	Iron, Total	18	18	1.8E-02	5.1E+00			18	18	1.4E+03	3.2E+04		
	Lead, Dissolved	3	6	1.6E-03	2.4E-03	2.0E-03	2.0E-03						
	Lead, Total	12	18	1.8E-03	3.6E-03	1.0E-03	2.0E-03	18	18	1.6E+00	5.0E+01		
	Magnesium, Dissolved	6	6	1.3E+01	2.1E+01								
	Magnesium, Total	18	18	8.9E+00	2.2E+01			18	18	3.9E+02	1.8E+04		
	Manganese, Dissolved	6	6	1.2E-03	1.4E-01								
	Manganese, Total	18	18	5.8E-03	1.7E-01			18	18	1.3E+01	1.2E+03		
	Mercury, Dissolved	0	6			1.0E-04	2.0E-04						
	Mercury, Total	0	18			1.0E-04	2.0E-04	0	18			5.0E-02	2.6E-01
	Nickel, Dissolved	2	6	6.5E-03	1.0E-02	5.0E-03	5.0E-03						
	Nickel, Total	2	18	7.5E-03	1.0E-02	3.0E-03	9.0E-03	17	18	1.3E+00	3.5E+01	2.1E+00	2.1E+00
	Potassium, Dissolved	6	6	1.4E+00	1.9E+00								
	Potassium, Total	18	18	1.4E+00	3.6E+00			18	18	8.2E+01	1.2E+03		
	Selenium, Dissolved	2	6	4.0E-03	4.3E-03	4.0E-03	4.0E-03						
	Selenium, Total	0	18			1.5E-03	4.0E-03	11	18	4.9E-01	7.4E+00	6.5E-01	2.1E+00
	Silver, Dissolved	0	6			2.5E-03	5.0E-03						
	Silver, Total	1	18	4.2E-03	4.2E-03	2.0E-03	5.0E-03	1	18	1.1E+00	1.1E+00	4.7E-01	2.3E+00
	Sodium, Dissolved	6	6	7.9E+00	1.3E+01								
	Sodium, Total	18	18	7.5E+00	1.3E+01			18	18	1.8E+01	2.6E+02		
	Thallium, Dissolved	0	6			5.0E-04	5.0E-03						
	Thallium, Total	1	18	1.3E-03	1.3E-03	5.0E-04	2.0E-03	1	12	1.1E+01	1.1E+01	3.2E-01	8.7E-01
	Vanadium, Dissolved	3	6	1.7E-03	2.1E-03	2.0E-03	2.0E-03						
	Vanadium, Total	1	18	3.5E-03	3.5E-03	1.5E-03	5.0E-03	18	18	2.7E+00	3.5E+01		
	Zinc, Dissolved	6	6	7.9E-03	1.6E-02								
	Zinc, Total	12	18	5.5E-03	3.8E-02	3.5E-03	7.0E-03	18	18	5.7E+00	9.8E+01		
	Cyanide, Total	0	18			5.0E-03	1.0E-02	0	18			6.0E-01	1.4E+01
OTHER	Bromide, Dissolved	3	12	1.0E-01	1.0E-01	5.0E-02	1.0E-01						
	Chloride, Cl	12	12	1.9E+01	3.8E+01								
	Nitrogen, Ammonia (NH3)	0	12			5.0E-02	1.0E-01						
	Nitrogen, Nitrate + Nitrite	7	12	1.7E-01	7.6E-01	1.0E-01	8.4E-01						
	Sulfate, SO4	12	12	4.2E+01	1.6E+02								
	TP (Total Phosphorus)	12	12	2.0E-02	8.0E-02								

TABLE A1-3   SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN BACKGROUND SOIL AND GROUNDWATER SAMPLES

		BACKGROUND SOIL SAMPLES						BACKGROUND GROUNDWATER SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
VOLATILES	1,1,1-Trichloroethane	2	20	2.0E-03	3.0E-03	2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	1,1,2,2-Tetrachloroethane	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	1,1,2-Trichloroethane	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	1,1-Dichloroethane	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	1,1-Dichloroethene	7	20	3.8E-03	1.3E-02	5.0E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	1,2-Dichloroethane	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	1,2-Dichloroethene(total)	1	20	1.0E-03	1.0E-03	2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	1,2-Dichloropropane	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	2-Butanone	0	12			1.1E-02	5.7E-02	0	14			1.0E-02	1.0E-02
	2-Hexanone	0	20			5.5E-03	5.7E-02	0	14			1.0E-02	1.0E-02
	4-Methyl-2-pentanone	0	20			5.5E-03	5.7E-02	0	14			1.0E-02	1.0E-02
	Acetone	11	20	9.0E-03	9.5E-01	1.1E-02	3.1E-02	2	14	2.0E-03	2.7E-02	1.0E-02	1.2E-02
	Benzene	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	Bromodichloromethane	0	20			2.5E-03	2.8E-02	4	14	2.0E-03	7.0E-03	5.0E-03	1.0E-02
	Bromoform	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	Bromomethane	0	20			5.5E-03	5.7E-02	0	11			1.0E-02	1.0E-02
	Carbon Disulfide	1	20	3.0E-02	3.0E-02	2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	Carbon Tetrachloride	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	Chlorobenzene	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	Chloroethane	0	20			5.5E-03	5.7E-02	0	14			1.0E-02	1.0E-02
	Chloroform	0	20			2.5E-03	2.8E-02	3	14	4.0E-03	2.6E-02	5.0E-03	1.0E-02
	Chloromethane	0	20			5.5E-03	5.7E-02	1	11	5.0E-03	5.0E-03	1.0E-02	1.0E-02
	cis-1,3-Dichloropropene	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	Dibromochloromethane	0	20			2.5E-03	2.8E-02	3	14	2.0E-03	5.0E-03	5.0E-03	1.0E-02
	Ethyl Benzene	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	Methylene Chloride	4	20	3.0E-03	5.5E-02	3.0E-03	1.5E-02	3	14	1.0E-03	1.9E-02	5.0E-03	1.0E-02
	Styrene	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	Tetrachloroethene	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	Toluene	9	20	2.0E-03	4.3E-02	5.0E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	trans-1,3-Dichloropropene	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
	Trichloroethene	0	20			2.5E-03	2.8E-02	1	14	2.0E-03	2.0E-03	5.0E-03	1.0E-02
	Vinyl Acetate	0	20			5.5E-03	5.7E-02	0	8			1.0E-02	1.0E-02
	Vinyl Chloride	0	20			5.5E-03	5.7E-02	0	11			1.0E-02	1.0E-02
	Xylenes (Total)	0	20			2.5E-03	2.8E-02	0	14			5.0E-03	1.0E-02
SEMIVOLATILES	1,2,4-Trichlorobenzene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	1,2-Dichlorobenzene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	1,3-Dichlorobenzene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	1,4-Dichlorobenzene	5	20	7.5E-02	1.1E-01	2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	2,4,5-Trichlorophenol	0	20			1.3E+00	3.8E+00	0	12			2.5E-02	5.0E-02
	2,4,6-Trichlorophenol	0	20			2.7E-01	7.8E-01	0	12			1.0E-02	1.0E-02
	2,4-Dichlorophenol	0	20			2.7E-01	7.8E-01	0	12			1.0E-02	1.0E-02
	2,4-Dimethylphenol	0	20			2.7E-01	7.8E-01	0	12			1.0E-02	1.0E-02
	2,4-Dinitrophenol	0	20			1.3E+00	3.8E+00	0	12			2.5E-02	5.0E-02
	2,4-Dinitrotoluene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	2,6-Dinitrotoluene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	2-Chloronaphthalene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	2-Chlorophenol	0	20			2.7E-01	7.8E-01	0	12			1.0E-02	1.0E-02
	2-Methylnaphthalene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	2-Methylphenol	0	20			2.7E-01	7.8E-01	0	12			1.0E-02	1.0E-02

TABLE A1-3 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN BACKGROUND SOIL AND GROUNDWATER SAMPLES

		BACKGROUND SOIL SAMPLES						BACKGROUND GROUNDWATER SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	2-Nitroaniline	0	20			1.3E+00	3.8E+00	0	14			2.5E-02	5.0E-02
	2-Nitrophenol	0	20			2.7E-01	7.8E-01	0	12			1.0E-02	1.0E-02
	3,3-Dichlorobenzidine	0	20			5.3E-01	1.6E+00	0	14			1.0E-02	2.0E-02
	3-Nitroaniline	0	20			1.3E+00	3.8E+00	0	14			2.5E-02	5.0E-02
	4,6-Dinitro-2-methylphenol	0	20			1.3E+00	3.8E+00	0	12			2.5E-02	5.0E-02
	4-Bromophenyl-phenylether	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	4-Chloro-3-methylphenol	0	20			2.7E-01	7.8E-01	0	12			1.0E-02	1.0E-02
	4-Chloroaniline	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	4-Chlorophenyl-phenyl ether	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	4-Methylphenol	0	20			2.7E-01	7.8E-01	0	12			1.0E-02	1.0E-02
	4-Nitroaniline	0	20			1.3E+00	3.8E+00	0	14			2.5E-02	5.0E-02
	4-Nitrophenol	0	20			1.3E+00	3.8E+00	0	12			2.5E-02	5.0E-02
	Acenaphthene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Acenaphthylene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Anthracene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Benzo(a)anthracene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Benzo(a)pyrene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Benzo(b)fluoranthene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Benzo(g,h,i)perylene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Benzo(k)fluoranthene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Benzoic acid	0	20			1.3E+00	3.8E+00	0	8			5.0E-02	5.0E-02
	Benzyl alcohol	0	20			2.7E-01	7.8E-01	0	8			1.0E-02	1.0E-02
	bis(2-Chloroethoxy) methane	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	bis(2-Chloroethyl) ether	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	bis(2-Chloroisopropyl) ether	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	bis(2-Ethylhexyl)phthalate	15	20	3.8E-02	4.0E+00	2.7E-01	4.0E-01	5	14	3.0E-03	3.2E-02	1.0E-02	1.0E-02
	Butylbenzylphthalate	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Carbazole							0	6			1.0E-02	1.0E-02
	Chrysene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Di-n-butylphthalate	4	20	9.2E-02	1.3E-01	2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Di-n-octylphthalate	0	20			2.7E-01	7.8E-01	1	14	2.0E-03	2.0E-03	1.0E-02	1.0E-02
	Dibenzo(a,h)anthracene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Dibenzofuran	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Diethylphthalate	1	20	1.4E-01	1.4E-01	2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Dimethylphthalate	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Fluoranthene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Fluorene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Hexachlorobenzene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Hexachlorobutadiene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Hexachlorocyclopentadiene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Hexachloroethane	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Indeno(1,2,3-cd)pyrene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Isophorone	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	N-Nitrosodinpropylamine	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	N-nitrosodiphenylamine	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Naphthalene	0	20			2.7E-01	7.8E-01	1	14	2.0E-03	2.0E-03	1.0E-02	1.0E-02
	Nitrobenzene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Pentachlorophenol	0	20			1.3E+00	3.8E+00	0	12			2.5E-02	5.0E-02
	Phenanthrene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
	Phenol	0	20			2.7E-01	7.8E-01	0	12			1.0E-02	1.0E-02

TABLE A1-3 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN BACKGROUND SOIL AND GROUNDWATER SAMPLES

		BACKGROUND SOIL SAMPLES						BACKGROUND GROUNDWATER SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	Pyrene	0	20			2.7E-01	7.8E-01	0	14			1.0E-02	1.0E-02
PESTICIDES	4,4-DDD	0	20			1.3E-02	3.8E-02	0	14			1.0E-04	1.1E-04
	4,4-DDE	0	20			1.3E-02	3.8E-02	0	14			1.0E-04	1.1E-04
	4,4-DDT	0	20			1.3E-02	3.8E-02	0	14			1.0E-04	1.1E-04
	Aldrin	0	20			6.4E-03	1.9E-02	0	14			5.0E-05	5.3E-05
	alpha-BHC	0	20			6.4E-03	1.9E-02	0	14			5.0E-05	5.3E-05
	alpha-Chlordane	0	20			6.4E-02	1.9E-01	0	14			5.0E-05	5.3E-04
	Aroclor-1016	0	20			6.4E-02	1.9E-01	0	14			5.0E-04	1.0E-03
	Aroclor-1221	0	20			6.4E-02	1.9E-01	0	14			5.0E-04	2.0E-03
	Aroclor-1232	0	20			6.4E-02	1.9E-01	0	14			5.0E-04	1.0E-03
	Aroclor-1242	0	20			6.4E-02	1.9E-01	0	14			5.0E-04	1.0E-03
	Aroclor-1248	0	20			6.4E-02	1.9E-01	0	14			5.0E-04	1.0E-03
	Aroclor-1254	0	20			1.3E-01	3.8E-01	0	14			1.0E-03	1.1E-03
	Aroclor-1260	0	20			1.3E-01	3.8E-01	0	14			1.0E-03	1.1E-03
	beta-BHC	0	20			6.4E-03	1.9E-02	0	14			5.0E-05	5.3E-05
	delta-BHC	0	20			6.4E-03	1.9E-02	0	14			5.0E-05	5.3E-05
	Dieldrin	0	20			1.3E-02	3.8E-02	0	14			1.0E-04	1.1E-04
	Endosulfan I	0	20			6.4E-03	1.9E-02	0	14			5.0E-05	5.3E-05
	Endosulfan II	0	20			1.3E-02	3.8E-02	0	14			1.0E-04	1.1E-04
	Endosulfan sulfate	0	20			1.3E-02	3.8E-02	0	14			1.0E-04	1.1E-04
	Endrin	0	20			1.3E-02	3.8E-02	0	14			1.0E-04	1.1E-04
	Endrin aldehyde							0	6			1.0E-04	1.0E-04
	Endrin ketone	0	20			1.3E-02	3.8E-02	0	14			1.0E-04	1.1E-04
	gamma-BHC (lindane)	0	20			6.4E-03	1.9E-02	0	14			5.0E-05	5.3E-05
	gamma-Chlordane	0	20			6.4E-02	1.9E-01	0	14			5.0E-05	5.3E-04
	Heptachlor	0	20			6.4E-03	1.9E-02	0	14			5.0E-05	5.3E-05
	Heptachlor epoxide	0	20			6.4E-03	1.9E-02	0	14			5.0E-05	5.3E-05
	Methoxychlor	0	20			6.4E-02	1.9E-01	0	14			5.0E-04	5.3E-04
	Toxaphene	0	20			1.3E-01	3.8E-01	0	14			1.0E-03	5.0E-03
INORGANICS	Aluminum, Dissolved							7	14	3.6E-02	1.7E-01	2.5E-02	3.6E-02
	Aluminum, Total	20	20	4.0E+02	5.7E+03			13	14	3.3E-02	6.9E+00	2.5E-02	2.5E-02
	Antimony, Dissolved							3	14	1.4E-02	6.3E-02	1.3E-02	3.7E-02
	Antimony, Total	3	20	5.3E+00	6.6E+00	3.7E+00	1.1E+01	2	14	3.6E-02	4.9E-02	1.3E-02	3.7E-02
	Arsenic, Dissolved							1	14	1.1E-03	1.1E-03	2.0E-03	3.0E-03
	Arsenic, Total	17	20	2.8E-01	5.6E+00	2.3E-01	4.3E-01	3	14	4.0E-03	5.8E-03	1.0E-03	3.0E-03
	Barium, Dissolved							14	14	2.0E-02	1.1E-01		
	Barium, Total	20	20	2.4E+00	6.2E+01			14	14	2.3E-02	1.2E-01		
	Beryllium, Dissolved							0	14			1.0E-03	3.0E-03
	Beryllium, Total	9	20	2.7E-01	7.1E-01	2.1E-01	4.7E-01	3	14	1.2E-03	4.5E-03	1.0E-03	3.0E-03
	Cadmium, Dissolved							0	14			1.0E-03	5.0E-03
	Cadmium, Total	0	20			4.4E-01	1.2E+00	0	14			1.0E-03	5.0E-03
	Calcium, Dissolved							14	14	5.2E+01	2.2E+02		
	Calcium, Total	20	20	1.6E+02	1.2E+05			14	14	5.1E+01	2.1E+02		
	Chromium, Dissolved							0	14			2.0E-03	6.0E-03
	Chromium, Total	19	20	2.1E+00	6.7E+01	1.6E+00	1.6E+00	5	14	2.8E-03	2.5E-02	2.0E-03	6.0E-03
	Cobalt, Dissolved							0	14			3.0E-03	1.2E-02
	Cobalt, Total	15	20	1.7E+00	4.5E+00	1.4E+00	1.5E+00	2	14	7.3E-03	2.5E-02	3.0E-03	1.3E-02
	Copper, Dissolved							3	14	4.9E-03	4.9E-03	3.0E-03	6.0E-03

TABLE A1-3 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN BACKGROUND SOIL AND GROUNDWATER SAMPLES

		BACKGROUND SOIL SAMPLES						BACKGROUND GROUNDWATER SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	Copper, Total	20	20	2.5E+00	5.8E+00			9	14	4.8E-03	3.2E-02	6.0E-03	6.0E-03
	Iron, Dissolved							10	14	3.0E-02	5.1E-01	1.0E-02	1.5E-02
	Iron, Total	20	20	1.4E+03	8.4E+03			13	14	5.7E-02	1.7E+01	1.5E-02	1.5E-02
	Lead, Dissolved							3	12	1.2E-03	1.9E-03	1.0E-03	2.0E-02
	Lead, Total	20	20	1.1E+00	8.1E+00			8	13	1.2E-03	9.1E-02	1.0E-03	2.0E-02
	Magnesium, Dissolved							14	14	9.8E+00	4.2E+01		
	Magnesium, Total	20	20	4.2E+02	1.1E+04			14	14	1.1E+01	4.1E+01		
	Manganese, Dissolved							14	14	2.1E-03	4.4E-01		
	Manganese, Total	20	20	2.5E+01	4.2E+02			14	14	9.2E-03	1.9E+00		
	Mercury, Dissolved							0	14			2.0E-04	2.0E-04
	Mercury, Total	0	20			4.0E-02	2.2E-01	0	14			2.0E-04	2.0E-04
	Nickel, Dissolved							0	14			6.0E-03	2.5E-02
	Nickel, Total	12	20	3.8E+00	3.6E+01	3.7E+00	4.2E+00	1	14	4.8E-02	4.8E-02	6.0E-03	2.5E-02
	Potassium, Dissolved							11	14	9.0E-01	2.3E+00	7.2E-01	9.6E-01
	Potassium, Total	16	20	8.2E+01	3.0E+02	7.9E+01	1.7E+02	13	14	7.6E-01	2.1E+00	9.4E-01	9.4E-01
	Selenium, Dissolved							1	14	2.3E-03	2.3E-03	2.0E-03	2.0E-02
	Selenium, Total	4	20	1.9E-01	3.9E-01	2.1E-01	2.4E-01	2	14	2.4E-03	3.1E-03	2.0E-03	4.0E-03
	Silver, Dissolved							2	14	9.8E-03	1.2E-02	2.0E-03	7.0E-03
	Silver, Total	0	20			3.8E-01	9.3E-01	2	14	7.7E-03	9.0E-03	2.0E-03	7.0E-03
	Sodium, Dissolved							14	14	3.0E+00	5.2E+01		
	Sodium, Total	3	20	5.4E+01	8.7E+01	3.8E+01	1.3E+02	14	14	3.2E+00	5.1E+01		
	Thallium, Dissolved							0	14			3.0E-03	5.0E-03
	Thallium, Total	0	20			3.3E-01	9.5E-01	0	14			3.0E-03	1.0E-02
	Vanadium, Dissolved							3	14	2.1E-03	1.3E-02	2.0E-03	8.9E-03
	Vanadium, Total	20	20	1.8E+00	1.4E+01			4	14	7.5E-03	2.7E-02	2.0E-03	8.5E-03
	Zinc, Dissolved							7	14	4.9E-03	7.0E-02	6.0E-03	1.0E-02
	Zinc, Total	20	20	4.5E+00	2.2E+01			10	14	7.4E-03	7.9E-02	6.0E-03	9.0E-03
	Cyanide, Total	1	20	2.0E-01	2.0E-01	1.6E-01	3.0E+00	0	13			1.0E-02	1.0E-02
OTHER	Bromide, Dissolved							5	9	1.0E-01	2.0E-01	1.0E-01	1.0E-01
	Chloride, Cl							7	7	5.9E+00	1.2E+02		
	Nitrogen, Ammonia (NH3)							5	8	1.0E-01	4.0E-01	4.0E+01	4.0E+01
	Nitrogen, Nitrate + Nitrite (NO2 + NO3)							1	4	6.9E+00	6.9E+00	4.0E+01	4.0E+01
	Sulfate, SO4							6	7	3.5E+01	4.3E+02	4.4E+01	4.4E+01
	TP (Total Phosphorus)							2	2	1.2E-01	2.7E-01		

TABLE A1-4 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN BACKGROUND SURFACE WATER AND SEDIMENT SAMPLES

		BACKGROUND SURFACE WATER SAMPLES						BACKGROUND SEDIMENT SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
VOLATILES	1,1,1-Trichloroethane	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	1,1,2,2-Tetrachloroethane	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	1,1,2-Trichloroethane	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	1,1-Dichloroethane	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	1,1-Dichloroethene	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	1,2-Dichloroethane	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	1,2-Dichloroethene(total)	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	1,2-Dichloropropane	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	2-Butanone	0	3			5.0E-03	1.0E-02	2	3	8.0E-03	2.8E-02	1.9E-02	1.9E-02
	2-Hexanone	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	4-Methyl-2-pentanone	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Acetone	2	3	4.5E-03	5.0E-03	1.0E-02	1.0E-02	1	3	1.8E-02	1.8E-02	4.6E-02	1.1E-01
	Benzene	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Bromodichloromethane	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Bromoform	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Bromomethane	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Carbon Disulfide	0	3			5.0E-03	1.0E-02	1	3	1.0E-02	1.0E-02	1.6E-02	1.9E-02
	Carbon Tetrachloride	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Chlorobenzene	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Chloroethane	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Chloroform	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Chloromethane	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	cis-1,3-Dichloropropene	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Dibromochloromethane	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Ethyl Benzene	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Methylene Chloride	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Styrene	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Tetrachloroethene	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Toluene	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	trans-1,3-Dichloropropene	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Trichloroethene	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Vinyl Chloride	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
	Xylenes (Total)	0	3			5.0E-03	1.0E-02	0	3			1.6E-02	3.0E-02
SEMIVOLATILES	1,2,4-Trichlorobenzene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	1,2-Dichlorobenzene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	1,3-Dichlorobenzene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	1,4-Dichlorobenzene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	2,4,5-Trichlorophenol	0	3			1.3E-02	2.5E-02	0	3			1.3E+00	2.4E+00
	2,4,6-Trichlorophenol	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	2,4-Dichlorophenol	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	2,4-Dimethylphenol	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	2,4-Dinitrophenol	0	3			1.3E-02	2.5E-02	0	3			1.3E+00	2.4E+00
	2,4-Dinitrotoluene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	2,6-Dinitrotoluene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	2-Chloronaphthalene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	2-Chlorophenol	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	2-Methylnaphthalene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	2-Methylphenol	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	2-Nitroaniline	0	3			1.3E-02	2.5E-02	0	3			1.3E+00	2.4E+00

TABLE A1-4 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN BACKGROUND SURFACE WATER AND SEDIMENT SAMPLES

		BACKGROUND SURFACE WATER SAMPLES						BACKGROUND SEDIMENT SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	2-Nitrophenol	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	3,3-Dichlorobenzidine	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	3-Nitroaniline	0	1			2.5E-02	2.5E-02	0	3			1.3E+00	2.4E+00
	4,6-Dinitro-2-methylphenol	0	3			1.3E-02	2.5E-02	0	3			1.3E+00	2.4E+00
	4-Bromophenyl-phenylether	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	4-Chloro-3-methylphenol	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	4-Chloroaniline	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	4-Chlorophenyl-phenyl ether	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	4-Methylphenol	0	3			5.0E-03	1.0E-02	1	3	3.5E-01	3.5E-01	6.2E-01	1.0E+00
	4-Nitroaniline	0	3			1.3E-02	2.5E-02	0	3			1.3E+00	2.4E+00
	4-Nitrophenol	0	3			1.3E-02	2.5E-02	0	3			1.3E+00	2.4E+00
	Acenaphthene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Acenaphthylene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Anthracene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Benzo(a)anthracene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Benzo(a)pyrene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Benzo(b)fluoranthene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Benzo(g,h,i)perylene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Benzo(k)fluoranthene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	bis(2-Chloroethoxy) methane	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	bis(2-Chloroethyl) ether	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	bis(2-Chloroisopropyl) ether	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	bis(2-Ethylhexyl)phthalate	2	3	7.0E-04	3.5E-03	1.0E-02	1.0E-02	0	3			5.4E-01	1.0E+00
	Butylbenzylphthalate	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Carbazole	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Chrysene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Di-n-butylphthalate	2	3	6.0E-04	7.5E-04	1.0E-02	1.0E-02	0	3			5.4E-01	1.0E+00
	Di-n-octylphthalate	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Dibenzo(a,h)anthracene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Dibenzofuran	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Diethylphthalate	0	3			5.0E-03	1.0E-02	1	3	1.4E-01	1.4E-01	5.4E-01	1.0E+00
	Dimethylphthalate	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Fluoranthene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Fluorene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Hexachlorobenzene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Hexachlorobutadiene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Hexachlorocyclopentadiene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Hexachloroethane	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Indeno(1,2,3-cd)pyrene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Isophorone	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	N-Nitrosodinpropylamine	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	N-nitrosodiphenylamine	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Naphthalene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Nitrobenzene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Pentachlorophenol	0	3			1.3E-02	2.5E-02	0	3			1.3E+00	2.4E+00
	Phenanthrene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Phenol	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
	Pyrene	0	3			5.0E-03	1.0E-02	0	3			5.4E-01	1.0E+00
PESTICIDES	4,4-DDD	0	3			5.0E-05	1.0E-04	0	3			5.4E-03	1.0E-02

TABLE A1-4 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN BACKGROUND SURFACE WATER AND SEDIMENT SAMPLES

		BACKGROUND SURFACE WATER SAMPLES						BACKGROUND SEDIMENT SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	4,4-DDE	0	3			5.0E-05	1.0E-04	0	3			5.4E-03	1.0E-02
	4,4-DDT	0	3			5.0E-05	1.0E-04	0	3			5.4E-03	1.0E-02
	Aldrin	0	3			2.5E-05	5.0E-05	0	3			2.8E-03	5.2E-03
	alpha-BHC	0	3			2.5E-05	5.0E-05	0	3			2.8E-03	5.2E-03
	alpha-Chlordane	0	3			2.5E-05	5.0E-05	0	3			2.8E-03	5.2E-03
	Aroclor-1016	0	3			5.0E-04	1.0E-03	0	3			5.4E-02	1.0E-01
	Aroclor-1221	0	3			1.0E-03	2.0E-03	0	3			1.1E-01	2.0E-01
	Aroclor-1232	0	3			5.0E-04	1.0E-03	0	3			5.4E-02	1.0E-01
	Aroclor-1242	0	3			5.0E-04	1.0E-03	0	3			5.4E-02	1.0E-01
	Aroclor-1248	0	3			5.0E-04	1.0E-03	0	3			5.4E-02	1.0E-01
	Aroclor-1254	0	3			5.0E-04	1.0E-03	0	3			5.4E-02	1.0E-01
	Aroclor-1260	0	3			5.0E-04	1.0E-03	0	3			5.4E-02	1.0E-01
	beta-BHC	0	3			2.5E-05	5.0E-05	0	3			2.8E-03	5.2E-03
	delta-BHC	0	3			2.5E-05	5.0E-05	0	3			2.8E-03	5.2E-03
	Dieldrin	0	3			5.0E-05	1.0E-04	0	3			5.4E-03	1.0E-02
	Endosulfan I	0	3			2.5E-05	5.0E-05	0	3			2.8E-03	5.2E-03
	Endosulfan II	0	3			5.0E-05	1.0E-04	0	3			5.4E-03	1.0E-02
	Endosulfan sulfate	0	3			5.0E-05	1.0E-04	0	3			5.4E-03	1.0E-02
	Endrin	0	3			5.0E-05	1.0E-04	0	3			5.4E-03	1.0E-02
	Endrin aldehyde	0	3			5.0E-05	1.0E-04	0	3			5.4E-03	1.0E-02
	Endrin ketone	0	3			5.0E-05	1.0E-04	0	3			5.4E-03	1.0E-02
	gamma-BHC (lindane)	0	3			2.5E-05	5.0E-05	0	3			2.8E-03	5.2E-03
	gamma-Chlordane	0	3			2.5E-05	5.0E-05	0	3			2.8E-03	5.2E-03
	Heptachlor	0	3			2.5E-05	5.0E-05	0	3			2.8E-03	5.2E-03
	Heptachlor epoxide	0	3			2.5E-05	5.0E-05	0	3			2.8E-03	5.2E-03
	Methoxychlor	0	3			2.5E-04	5.0E-04	0	3			2.8E-02	5.2E-02
	Toxaphene	0	3			2.5E-03	5.0E-03	0	3			2.8E-01	5.2E-01
INORGANICS	Aluminum, Dissolved	3	3	2.6E-02	2.8E-02								
	Aluminum, Total	3	3	5.5E-02	8.6E-01			3	3	4.4E+03	1.5E+04		
	Antimony, Dissolved	0	3			7.0E-03	1.4E-02						
	Antimony, Total	0	3			2.4E-02	4.7E-02	0	3			1.6E+01	3.1E+01
	Arsenic, Dissolved	2	3	1.9E-03	2.4E-03	2.0E-03	2.0E-03						
	Arsenic, Total	0	3			1.0E-03	2.0E-03	3	3	4.2E+00	2.1E+01		
	Barium, Dissolved	3	3	8.3E-03	1.8E-02								
	Barium, Total	3	3	6.5E-03	1.8E-02			3	3	3.2E+01	1.2E+02		
	Beryllium, Dissolved	0	3			5.0E-04	1.0E-03						
	Beryllium, Total	0	3			5.0E-04	1.0E-03	3	3	4.5E-01	1.1E+00		
	Cadmium, Dissolved	1	3	1.2E-03	1.2E-03	5.0E-04	1.0E-03						
	Cadmium, Total	0	3			1.5E-03	3.0E-03	0	3			1.0E+00	2.0E+00
	Calcium, Dissolved	3	3	1.0E+01	2.3E+01								
	Calcium, Total	3	3	1.1E+01	2.3E+01			3	3	2.2E+04	7.3E+04		
	Chromium, Dissolved	0	3			1.0E-03	2.0E-03						
	Chromium, Total	0	3			3.0E-03	6.0E-03	3	3	6.8E+00	1.5E+01		
	Cobalt, Dissolved	0	3			1.0E-03	2.0E-03						
	Cobalt, Total	0	3			4.0E-03	8.0E-03	2	3	7.3E+00	1.8E+01	2.7E+00	2.7E+00
	Copper, Dissolved	0	3			1.0E-03	2.0E-03						
	Copper, Total	0	3			2.5E-03	5.0E-03	3	3	1.4E+01	2.8E+01		
	Iron, Dissolved	3	3	1.1E-02	6.7E-02								
	Iron, Total	3	3	1.9E-02	1.8E-01			3	3	8.6E+03	2.5E+04		

TABLE A1-4 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN BACKGROUND SURFACE WATER AND SEDIMENT SAMPLES

		BACKGROUND SURFACE WATER SAMPLES						BACKGROUND SEDIMENT SAMPLES					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	Lead, Dissolved	2	3	1.7E-03	2.1E-03	2.0E-03	2.0E-03						
	Lead, Total	0	3			1.0E-03	2.0E-03	3	3	1.0E+01	3.4E+01		
	Magnesium, Dissolved	3	3	8.0E+00	1.6E+01								
	Magnesium, Total	3	3	8.1E+00	1.6E+01			3	3	3.8E+03	9.4E+03		
	Manganese, Dissolved	2	3	1.8E-03	1.9E-03	5.0E-04	5.0E-04						
	Manganese, Total	3	3	1.8E-02	5.3E-02			3	3	1.5E+02	7.0E+02		
	Mercury, Dissolved	0	3			1.0E-04	2.0E-04						
	Mercury, Total	0	3			1.0E-04	2.0E-04	0	3			1.5E-01	3.0E-01
	Nickel, Dissolved	0	3			2.5E-03	5.0E-03						
	Nickel, Total	0	3			4.5E-03	9.0E-03	3	3	4.9E+00	2.6E+01		
	Potassium, Dissolved	3	3	3.7E-01	7.6E-01								
	Potassium, Total	3	3	4.1E-01	9.6E-01			3	3	3.0E+02	7.4E+02		
	Selenium, Dissolved	0	3			2.0E-03	4.0E-03						
	Selenium, Total	0	3			2.0E-03	4.0E-03	0	3			1.3E+00	2.7E+00
	Silver, Dissolved	0	3			2.5E-03	5.0E-03						
	Silver, Total	0	3			2.0E-03	4.0E-03	0	3			1.3E+00	2.6E+00
	Sodium, Dissolved	3	3	9.0E+00	1.8E+01								
	Sodium, Total	3	3	9.3E+00	1.8E+01			3	3	9.0E+01	2.4E+02		
	Thallium, Dissolved	0	3			5.0E-04	1.0E-03						
	Thallium, Total	0	3			5.0E-04	1.0E-03	1	1	4.3E-01	4.3E-01		
	Vanadium, Dissolved	2	3	1.7E-03	2.0E-03	2.0E-03	2.0E-03						
	Vanadium, Total	0	3			2.5E-03	5.0E-03	3	3	1.0E+01	2.8E+01		
	Zinc, Dissolved	3	3	7.2E-03	8.9E-03								
	Zinc, Total	1	3	7.4E-03	7.4E-03	7.0E-03	7.0E-03	3	3	2.3E+01	7.7E+01		
	Cyanide, Total	0	3			5.0E-03	1.0E-02	0	3			8.1E+00	1.7E+01

TABLE A1-5 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN TRENCH LEACHATE SAMPLES

		LIQUID FRACTION						SOLID FRACTION					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
VOLATILES	1,1,1-Trichloroethane	2	3	7.5E-03	5.2E-01	1.0E-02	1.0E-02						
	1,1,2,2-Tetrachloroethane	0	3			5.0E-03	1.0E-01						
	1,1,2-Trichloroethane	0	3			5.0E-03	1.0E-01						
	1,1-Dichloroethane	3	3	5.0E-03	2.2E-01								
	1,1-Dichloroethene	0	3			5.0E-03	1.0E-01						
	1,2-Dichloroethane	0	3			5.0E-03	1.0E-01						
	1,2-Dichloroethene(total)	2	3	6.6E-02	4.1E-01	5.0E-03	5.0E-03						
	1,2-Dichloropropane	0	3			5.0E-03	1.0E-01						
	2-Butanone	2	3	1.3E-02	4.2E-01	5.0E-03	5.0E-03	1	1	4.1E+03	4.1E+03		
	2-Hexanone	0	3			5.0E-03	1.0E-01	2	2	5.7E+02	2.9E+04		
	4-Methyl-2-pentanone	2	3	9.0E-03	1.1E-01	5.0E-03	5.0E-03	2	2	4.1E+02	1.7E+04		
	Acetone	1	3	1.3E+00	1.3E+00	5.0E-03	2.3E-01	1	1	3.0E+02	3.0E+02		
	Benzene	2	3	3.2E-02	9.7E-02	5.0E-03	5.0E-03						
	Bromodichloromethane	0	3			5.0E-03	1.0E-01						
	Bromoform	0	3			5.0E-03	1.0E-01						
	Bromomethane	0	3			5.0E-03	1.0E-01						
	Carbon Disulfide	2	3	4.0E-03	1.3E-01	5.0E-03	5.0E-03						
	Carbon Tetrachloride	0	3			5.0E-03	1.0E-01						
	Chlorobenzene	0	3			5.0E-03	1.0E-01						
	Chloroethane	1	3	3.0E-03	3.0E-03	5.0E-03	1.0E-01						
	Chloroform	1	3	7.6E-02	7.6E-02	5.0E-03	1.0E-02						
	Chloromethane	0	3			5.0E-03	1.0E-01						
	cis-1,3-Dichloropropene	0	3			5.0E-03	1.0E-01						
	Dibromochloromethane	0	3			5.0E-03	1.0E-01						
	Ethyl Benzene	2	3	1.5E-01	6.4E-01	5.0E-03	5.0E-03	1	1	6.4E+03	6.4E+03		
	Methylene Chloride	1	3	5.5E-01	5.5E-01	5.0E-03	2.0E-02	1	1	2.6E+02	2.6E+02		
	Styrene	1	3	3.0E-03	3.0E-03	5.0E-03	1.0E-01						
	Tetrachloroethene	1	3	4.8E-02	4.8E-02	5.0E-03	1.0E-02						
	Toluene	2	3	6.3E-02	1.1E+00	5.0E-03	5.0E-03	2	2	8.5E+02	4.8E+05		
	trans-1,3-Dichloropropene	0	3			5.0E-03	1.0E-01						
	Trichloroethene	3	3	1.1E-02	5.5E-01								
	Vinyl Chloride	2	3	1.6E-02	4.7E-02	5.0E-03	5.0E-03						
	Xylenes (Total)	2	3	2.0E-01	3.3E-01	5.0E-03	5.0E-03	2	2	7.7E+01	4.4E+04		
SEMIVOLATILES	1,2,4-Trichlorobenzene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	1,2-Dichlorobenzene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	1,3-Dichlorobenzene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	1,4-Dichlorobenzene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	2,4,5-Trichlorophenol	0	1			2.5E-02	2.5E-02	0	2			9.1E+01	2.5E+03
	2,4,6-Trichlorophenol	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	2,4-Dichlorophenol	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	2,4-Dimethylphenol	2	3	1.0E-02	8.4E-02	1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	2,4-Dinitrophenol	0	1			2.5E-02	2.5E-02	0	2			9.1E+01	2.5E+03
	2,4-Dinitrotoluene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	2,6-Dinitrotoluene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	2-Chloronaphthalene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	2-Chlorophenol	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	2-Methylnaphthalene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	2-Methylphenol	2	3	1.0E-02	4.4E-01	1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	2-Nitroaniline	0	1			2.5E-02	2.5E-02	0	2			9.1E+01	2.5E+03

TABLE A1-5 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN TRENCH LEACHATE SAMPLES

		LIQUID FRACTION						SOLID FRACTION					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	2-Nitrophenol	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	3,3-Dichlorobenzidine	0	1			1.0E-02	1.0E-02	0	2			3.6E+01	1.0E+03
	3-Nitroaniline	0	1			2.5E-02	2.5E-02	0	2			9.1E+01	2.5E+03
	4,6-Dinitro-2-methylphenol	0	1			2.5E-02	2.5E-02	0	2			9.1E+01	2.5E+03
	4-Bromophenyl-phenylether	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	4-Chloro-3-methylphenol	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	4-Chloroaniline	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	4-Chlorophenyl-phenyl ether	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	4-Methylphenol	2	3	1.4E-01	4.2E+00	1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	4-Nitroaniline	0	1			2.5E-02	2.5E-02	0	2			9.1E+01	2.5E+03
	4-Nitrophenol	0	1			2.5E-02	2.5E-02	0	2			9.1E+01	2.5E+03
	Acenaphthene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Acenaphthylene	1	1	1.0E-03	1.0E-03			0	2			1.8E+01	5.0E+02
	Anthracene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Benzo(a)anthracene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Benzo(a)pyrene	1	1	4.0E-03	4.0E-03			0	2			1.8E+01	5.0E+02
	Benzo(b)fluoranthene	1	1	6.0E-03	6.0E-03			0	2			1.8E+01	5.0E+02
	Benzo(g,h,i)perylene	1	1	2.0E-03	2.0E-03			0	2			1.8E+01	5.0E+02
	Benzo(k)fluoranthene	1	1	2.0E-03	2.0E-03			0	2			1.8E+01	5.0E+02
	Benzoic acid							1	2	9.0E+00	9.0E+00	2.5E+03	2.5E+03
	Benzyl alcohol							1	2	1.1E+01	1.1E+01	5.0E+02	5.0E+02
	bis(2-Chloroethoxy) methane	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	bis(2-Chloroethyl) ether	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	bis(2-Chloroisopropyl) ether	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	bis(2-Ethylhexyl)phthalate	1	2	2.2E-02	2.2E-02	1.0E-02	1.0E-02	1	2	1.8E+02	1.8E+02	1.8E+01	1.8E+01
	Butylbenzylphthalate	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Carbazole	0	1			1.0E-02	1.0E-02						
	Chrysene	1	1	4.0E-03	4.0E-03			0	2			1.8E+01	5.0E+02
	Di-n-butylphthalate	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Di-n-octylphthalate	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Dibenzo(a,h)anthracene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Dibenzofuran	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Diethylphthalate	1	2	4.9E-02	4.9E-02	1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Dimethylphthalate	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Fluoranthene	1	1	6.0E-03	6.0E-03			0	2			1.8E+01	5.0E+02
	Fluorene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Hexachlorobenzene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Hexachlorobutadiene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Hexachlorocyclopentadiene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Hexachloroethane	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Indeno(1,2,3-cd)pyrene	1	1	2.0E-03	2.0E-03			0	2			1.8E+01	5.0E+02
	Isophorone	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	N-Nitrosodinpropylamine	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	N-nitrosodiphenylamine	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Naphthalene	1	1	3.0E-03	3.0E-03			1	2	4.5E+01	4.5E+01	1.8E+01	1.8E+01
	Nitrobenzene	0	1			1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Pentachlorophenol	0	1			2.5E-02	2.5E-02	0	2			9.1E+01	2.5E+03
	Phenanthrene	1	1	6.0E-03	6.0E-03			0	2			1.8E+01	5.0E+02
	Phenol	6	7	6.8E-03	6.6E+00	1.0E-02	1.0E-02	0	2			1.8E+01	5.0E+02
	Pyrene	1	1	6.0E-03	6.0E-03			0	2			1.8E+01	5.0E+02

TABLE A1-5 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN TRENCH LEACHATE SAMPLES

		LIQUID FRACTION						SOLID FRACTION					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	Decachlorobiphenyl							0	2			1.8E+02	5.0E+03
	Dichlorobiphenyl							0	2			9.1E+01	2.5E+03
	Heptachlorobiphenyl							0	2			9.1E+01	2.5E+03
	Hexachlorobiphenyl							0	2			9.1E+01	2.5E+03
	Monochlorobiphenyl							0	2			9.1E+01	2.5E+03
	Nonachlorobiphenyl							0	2			1.8E+02	5.0E+03
	Octachlorobiphenyl							0	2			1.8E+02	5.0E+03
	Pentachlorobiphenyl							0	2			9.1E+01	2.5E+03
	Tetrachlorobiphenyl							0	2			9.1E+01	2.5E+03
	Trichlorobiphenyl							0	2			9.1E+01	2.5E+03
PESTICIDES	4,4-DDD	0	3			5.0E-05	1.0E-03	0	2			1.8E+01	5.0E+02
	4,4-DDE	0	3			5.0E-05	1.0E-03	0	2			1.8E+01	5.0E+02
	4,4-DDT	1	3	2.9E-04	2.9E-04	5.0E-05	1.0E-03	0	2			1.8E+01	5.0E+02
	Aldrin	2	3	1.2E-04	1.3E-04	2.5E-05	2.5E-05	0	2			1.8E+01	5.0E+02
	alpha-BHC	1	3	1.7E-05	1.7E-05	2.5E-05	5.0E-04	0	2			1.8E+01	5.0E+02
	alpha-Chlordane	1	3	2.2E-04	2.2E-04	2.5E-05	5.0E-04	0	2			1.8E+01	5.0E+02
	Aroclor-1016	0	3			5.0E-04	1.0E-02	0	2			9.2E+00	9.6E+00
	Aroclor-1221	0	3			1.0E-03	2.0E-02	0	2			9.2E+00	9.6E+00
	Aroclor-1232	0	3			5.0E-04	1.0E-02	0	2			9.2E+00	9.6E+00
	Aroclor-1242	0	3			5.0E-04	1.0E-02	0	2			9.2E+00	9.6E+00
	Aroclor-1248	0	3			5.0E-04	1.0E-02	0	2			9.2E+00	9.6E+00
	Aroclor-1254	0	3			5.0E-04	1.0E-02	0	2			9.2E+00	9.6E+00
	Aroclor-1260	0	3			5.0E-04	1.0E-02	0	2			9.2E+00	9.6E+00
	beta-BHC	2	3	6.8E-05	9.7E-05	2.5E-05	2.5E-05	0	2			1.8E+01	5.0E+02
	delta-BHC	0	3			2.5E-05	5.0E-04	0	2			1.8E+01	5.0E+02
	Dieldrin	1	3	7.3E-05	7.3E-05	5.0E-05	1.0E-03	0	2			1.8E+01	5.0E+02
	Endosulfan I	0	3			2.5E-05	5.0E-04	0	2			1.8E+01	5.0E+02
	Endosulfan II	2	3	4.8E-05	1.7E-04	5.0E-05	5.0E-05	0	2			1.8E+01	5.0E+02
	Endosulfan sulfate	0	3			5.0E-05	1.0E-03	0	2			1.8E+01	5.0E+02
	Endrin	0	3			5.0E-05	1.0E-03	0	2			1.8E+01	5.0E+02
	Endrin aldehyde	0	3			5.0E-05	1.0E-03						
	Endrin ketone	0	3			5.0E-05	1.0E-03	0	2			1.8E+01	5.0E+02
	gamma-BHC (lindane)	0	3			2.5E-05	5.0E-04	0	2			1.8E+01	5.0E+02
	gamma-Chlordane	2	3	2.8E-05	2.9E-05	2.5E-05	2.5E-05	0	2			1.8E+01	5.0E+02
	Heptachlor	2	3	2.3E-05	1.2E-04	2.5E-05	2.5E-05	0	2			1.8E+01	5.0E+02
	Heptachlor epoxide	0	3			2.5E-05	5.0E-04	0	2			1.8E+01	5.0E+02
	Methoxychlor	0	3			2.5E-04	5.0E-03	0	2			1.8E+01	5.0E+02
	Toxaphene	0	3			2.5E-03	5.0E-02	0	2			4.6E+01	4.8E+01
INORGANICS	Aluminum, Total	0	4			4.2E+02	4.2E+02						
	Antimony, Total	2	4	6.8E-02	1.1E+01	9.6E+00	1.1E+01						
	Arsenic, Total	1	4	1.7E-02	1.7E-02	5.0E+00	5.6E+00						
	Barium, Total	0	4			1.9E+01	1.9E+01						
	Beryllium, Total	0	4			5.0E-04	8.0E+00						
	Cadmium, Total	2	4	3.8E-03	2.5E+00	1.2E+00	1.3E+00						
	Calcium, Total	2	4	1.7E+03	2.1E+03	1.6E+03	1.6E+03						
	Chromium, Total	4	4	3.2E-02	1.0E+01								
	Cobalt, Total	2	4	1.3E-02	3.3E+00	2.4E+00	2.7E+00						
	Copper, Total	0	4			1.3E+01	1.3E+01						

TABLE A1-5 SUMMARY OF FREQUENCY OF DETECTION AND RANGE OF CONCENTRATION OF CHEMICALS IN TRENCH LEACHATE SAMPLES

		LIQUID FRACTION						SOLID FRACTION					
		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/L)		RANGE OF NON-DETECTED VALUES (mg/L)		FREQ. OF DETECTION		RANGE OF DETECTED VALUES (mg/kg)		RANGE OF NON-DETECTED VALUES (mg/kg)	
CLASS	CHEMICAL	Hits	Total	Min	Max	Min	Max	Hits	Total	Min	Max	Min	Max
	Iron, Total	2	4	2.5E+02	2.7E+02	1.5E+02	1.5E+02						
	Lead, Total	2	4	4.4E-01	2.8E+01	1.4E+01	1.5E+01						
	Magnesium, Total	0	4			2.1E+02	2.1E+02						
	Manganese, Total	0	4			8.0E-01	1.7E+01						
	Mercury, Total	0	3			1.6E+00	1.6E+00						
	Nickel, Total	1	1	5.1E-02	5.1E-02								
	Potassium, Total	1	1	2.7E+01	2.7E+01								
	Selenium, Total	0	1			1.0E-03	1.0E-03						
	Silver, Total	0	1			1.0E-03	1.0E-03						
	Sodium, Total	2	4	8.2E+01	4.2E+02	8.0E+01	9.0E+01						
	Thallium, Total	0	4			1.0E-03	2.2E+00						
	Vanadium, Total	3	4	3.1E-02	4.5E+00	1.8E+00	1.8E+00						
	Zinc, Total	0	4			5.8E+02	5.8E+02						
	Cyanide, Total	2	4	9.8E-02	4.8E+01	1.0E+01	1.0E+01						
OTHER	Bromide, Dissolved	3	4	4.8E-01	3.3E+00	2.0E+02	2.0E+02						
	Chloride, Cl	4	4	1.8E+01	7.0E+01								
	Nitrogen, Ammonia (NH3)	4	4	1.6E+01	1.8E+02								
	Sulfate, SO4	0	4			3.9E+03	3.9E+03						
	TP (Total Phosphorus)	2	2	8.9E+00	9.3E+00								

TABLE A1-6 TENTATIVELY IDENTIFIED COMPOUNDS IDENTIFIED IN SITE SAMPLES

CHEMICAL NAME	NUMBER	RANGE MIN. (mg/kg)	RANGE MAX. (mg/kg)
.GAMMA.-SITOSTEROL	3	0.4	3.8
1,12-DODECANEDIOL	1	0.54	0.54
1,2-CYCLOHEXANEDIOL	2	4.1	4.7
15-OCTADECENAL	1	1.1	1.1
17-OCTADECENAL	1	1	1
1H-INDENE, 2,3-DIHYDRO-1,6-D	1	0.017	0.017
2-CYCLOHEXEN-1-ONE	6	1.3	4.4
2-CYCLOPENTEN-1-ONE, 2-METHYL	1	2.6	2.6
2-ETHOXYETHYL ACETATE	3	400	5300
2-PENTANONE, 4-HYDROXY-4-MET	2	29	31
2-PENTANONE,4-HYDROXY-4-METHYL	20	15	70
2-PROPANOL	7	0.0084	0.2
2-PROPANONE, 1-METHOXY-	2	0.029	0.072
3-CYCLOHEXEN-1-01	1	0.81	0.81
3-HEXENE-2,3-DIONE	1	1.7	1.7
3-HEXENE-2,5-DIONE	22	0.41	1.9
4-HYDROCY-4-METHYL-2-PENTANONE	1	33	33
4-HYDROXY-4-METHYL-2-PENTANONE	38	7	62
5-(2-PROPENYL)-1,3-BENZODIOXOL	1	0.4	0.4
9-HEXADECANOIC ACID	1	0.2	0.2
9-HEXADECENOIC ACID	6	1.02	4.2
BENZALDEHYDE	1	1.1	1.1
BENZENE, (1-METHYLETHYL)-	1	0.023	0.023
BENZENE, 1,1'-ETHYLIDENEBIS[	1	0.34	0.34
BENZENE, 1-ETHYL-2-METHYL-	1	0.039	0.039
BENZENE, 1-ETHYL-3-METHYL-	1	0.29	0.29
BENZENE, CYCLOHEXYL	1	0.81	0.81
BENZENE, CYCLOHEXYL-	3	0.35	0.85
BENZENE, METHYL-	2	0.5	0.7
BENZO[B]THIOPHENE	1	0.057	0.057
BENZO[C]THIOPHENE, 1,3-DIHYDRO	1	0.014	0.014
BENZO[C]THIOPNENE, 1,3-DIHYD	1	0.01	0.01
BENZO[J]FLUORANTHENE	2	1.9	3.6
CHOLESTANOL (VAN)	1	2.6	2.6
CHOLESTEROL	3	2.2	3.2
CYCLOHEXANE, BUTYL-	1	460	460
CYCLOHEXANE, PROPYL-	1	760	760
CYCLOHEXANOL, 4-CHLORO-, TRANS	1	43	43
CYCLOHEXANONE	2	310	490
CYCLOHEXENE, 3-CHLORO-	1	0.72	0.72
CYCLOPENTENE, 1-ETHYL-	1	1.8	1.8
CYCLOPROPANE, 1-CHLORO-2-ETHYL	1	0.45	0.45
DECANE	1	3200	3200
DOCOSANOIC ACID	1	1.34	1.34
DODECANE	1	410	410
DODECANOIC ACID	8	0.22	57
ERGOST-22-EN-3-OL, (3.ALPHA.	1	2.6	2.6
ERGOST-22-EN-3-ONE, (5.BETA.	1	1.84	1.84
ERGOST-5-EN-3-OL, (3.BETA.)-	2	1.06	1.12
ETHANE, 1,1,2,2-TETRACHLORO-	1	0.48	0.48
ETHANE, 1,1,2-TRICHLORO-1,2,	1	0.005	0.005
ETHANE, 1,1,2-TRICHLORO-1,2,2	2	0.034	0.045
ETHANE, 1,1,2-TRICHLORO-1,2,2-	8	0.006	0.03
ETHANETHIOIC ACID, S,S'-[THI	1	0.76	0.76
ETHANOL	3	0.0096	0.051
ETHANOL, 2-(2-ETHOXYETHOXY)-	5	0.076	0.14
HEXADECANOIC ACID	16	0.058	3.4
MOLECULAR SULFUR	5	0.24	3.4
NAPHTHALENE	1	0.7	0.7
NAPTHALENE	1	0.47	0.47
NONANAL	1	0.0082	0.0082
NONANE	1	2000	2000
OCTADECANAL	2	1.3	1.6
OCTADECANOIC ACID	3	0.36	1.44

Table A1-6 - continued

CHEMICAL NAME	NUMBER	RANGE MIN. (mg/kg)	MAX. (mg/kg)
PHENANTHRENE, 1-METHYL-7-(1-	2	0.35	0.6
PHENOL, 2,4-BIS(1,1-DIMETHYL	5	0.074	0.146
PROPANOIC ACID, 2-METHYL-, B	1	9000	9000
STIGMASTEROL	3	1.1	1.68
SULFUR, MOL	1	3.3	3.3
SULFUR, MOL (S8)	17	0.25	16
TETRADECANOIC ACID	5	0.138	0.54
UNDECANE	1	2400	2400

Table A1-6 - continued

CHEMICAL NAME	NUMBER	RANGE MIN. (mg/L)	MAX. (mg/L)
1,1,2-TRICHLORO-1,2,2-TRIFLUOR	3	0.008	0.013
1-BUTANOL	2	0.01	0.02
1-BUTENE	1	0.008	0.008
1-PENTENE, 4,4-DIMETHYL-	1	0.02	0.02
1-PROPENE, 2-METHYL-	2	0.005	0.006
2-PROPANOL	4	0.006	0.08
CHOLESTEROL	2	0.008	0.012
CYCLOHEXANE, BROMO-	4	0.002	0.005
CYCLOHEXANOL	5	0.003	0.028
CYCLOTRISILOXANE, HEXAMETHYL	1	0.008	0.008
DECANOIC ACID	1	0.003	0.003
DODECANOIC ACID	1	0.011	0.011
ETHANE, 1,1'-OXYBIS-	1	0.03	0.03
ETHANE, 1,1,2-TRICHLORO-1,2,2	1	0.07	0.07
ETHANE, 1,1,2-TRICHLORO-1,2,2,	1	0.06	0.06
ETHANE, 1,1,2-TRICHOLOR-1,2,2-	1	0.09	0.09
ETHANOL, 2-CHLORO-, PHOSPHAT	1	0.002	0.002
ETHANOL, 2-CHLORO-, PHOSPHATE	2	0.02	0.2
ETHANOL, 2-CHLORO-,PHOSPHAT	1	0.003	0.003
ETHYL ETHER	11	0.007	0.11
ETHYL ETHER (8CI)	7	0.006	0.01
HEXADECANOIC ACID	1	0.005	0.005
HEXANE	13	0.004	0.005
HEXANOIC ACID, 6-AMINO-	1	0.2	0.2
METHANE, CHLOROFLUORO-	2	0.009	0.01
METHANE, DICHLOROFLUORO-	9	0.006	0.06
METHANE, TRICHLOROFLUORO-	1	0.67	0.67
METHANE,THIOBIS-	1	0.024	0.024
NONANOIC ACID	1	0.012	0.012
OCTADECANOIC ACID, 2-METHYLP	6	0.01	0.031
OCTANETHIOIC ACID, S-HEXYL E	1	0.4	0.4
OCTANOIC ACID	1	0.005	0.005
PHENOL, 4,4'-BUTYLIDENEBIS[2	1	0.2	0.2
PROPANE, BROMOTRIFLUORO-	1	0.016	0.016
PROPANOIC ACID, 2-METHYL-, B	1	0.03	0.03
SULFUR, MOL (S8)	3	0.003	0.46
SULFUR, MOL (S8) (8CI9CI)	6	0.006	0.09
TETRADECANOIC ACID	1	0.006	0.006
TETRADECANOIC ACID, 1-METHYL	1	0.003	0.003
THIOCYANIC ACID, 4-HYDROXYPH	1	0.064	0.064
[1,1'-BIPHENYL]-2-OL	1	0.091	0.091

APPENDIX 2

CALCULATION OF DUST CONCENTRATIONS IN AIR AT THE HIMCO DUMP SITE

1.0 INTRODUCTION

One pathway by which humans may be exposed to site contaminants at the Himco Dump site is by inhalation of airborne dust particles contaminated soil. These particles may be resuspended either from the force of the wind on the soil, or from mechanical erosion such as dirt-bike riding or agricultural tilling. This appendix describes how the concentrations of respirable dust particles (PM_{10}) in air were estimated at each exposure point where air emissions were considered to be a potential exposure pathway. The concentrations of individual chemicals of potential concern were then obtained by multiplying the PM_{10} concentrations (kg/m^3) by the concentrations of contaminants of potential concern in soil (mg/kg).

2.0 EMISSION RATE FROM WIND EROSION - CURRENT AND FUTURE LAND USES

The rate of soil erosion due to wind action is a complex function of wind speed, particle size distribution, extent of ground covered with vegetation and "roughness" of the surrounding terrain. It is assumed that the erodible surfaces of the site include the landfill area and the worn foot and bike trail south of the quarry pit pond. Based on the composition of capping material (sand and calcium sulfate) and the discontinuous vegetation, emission rates were calculated based on the unlimited erosion potential equation (Cowherd et al. 1985), as follows:

$$E = 0.036\ (1-V)(u/ut)^3 F(x) \qquad (1)$$

where:

E = PM_{10} emission factor ($g/m^2/hr$)
V = fraction of surface vegetative cover
u = mean annual wind speed (m/s)
ut = threshold value of wind speed at 2.25 m/s
x = 0.886 ut/u
$F(x)$ = function of x plotted in Cowherd et al. (1985), Figure 4-3

Values for each of these parameters were derived or estimated as follows:

V — The value for vegetative cover was estimated at 50% based on site characteristics observed on a site visit by Life Systems' personnel.

u — The average annual wind speed was calculated as 2.25 m/s (5.03 mph) based on meterology information from the South Bend/St. Joe weather station (GSC 1989).

ut — The value of ut is a function of the Threshold Friction Velocity (TFV) and the roughness height (Z_0). Estimation of the TFV requires information on the mode of the particle size distribution in soil. The aggregate size distribution mode was calculated from the particle size distribution data provided by Donohue & Associates. The data included an analysis for five surface soil samples (GE-01, GE-05 and HS03-05) on the capped landfill and dirt bike trail (refer to Figure 2-1). The TFV was then estimated, based on the graph in Figure 3-4 of Cowherd et al. (1985) to be 35 cm/sec. The roughness height is a function of the height of natural and manmade objects in the vicinity of the source. Under current land use conditions, the capped landfilled area approximates a wheat field, thus the value of Z_0 was estimated to be 4 cm, based on the graph presented in Figure 3-6 of Cowherd et al. (1985). Employing this roughness height, the ratio of ut to TFV was estimated to be based on the graph in Figure 4-1 of Cowherd et al. (1985). Ut was then calculated by multiplying the TFV by 13, resulting in a value for ut of 4.6 m/s. Under future land use conditions (soybean or corn fields), the values are assumed to be the same.

x This value is calculated as 0.886 (ut/u).

F(x) The F(x) value was estimated from the graph in Figure 4-3 of Cowherd et al. (1985) to be 0.5.

The emission rate was then calculated as follows:

$$E = 0.036\ (1-0.5)(2.25/4.6)^3(0.5)$$
$$= 1.05E\text{-}03\ g/m^2/hr$$

This emission rate was then divided by 3,600 sec/hr to obtain an emission rate of 2.9E-07 $g/m^2/sec$ or 2.9E-10 $kg/m^2/sec$.

3.0 EMISSION RATE FROM DIRT-BIKE RIDING - CURRENT LAND USE

The rate of soil emissions due to vehicular traffic is a function of vehicle speed, weight and the number of wheels, along with the particle size distribution of the soil. Based on Cowherd et al. (1985), the basic equation for estimated emission rates from vehicular traffic on dirt surfaces per vehicle kilometer traveled (VKT) is:

$$E = 0.85 * (S/10) * (V/24)^{0.8} * (W/7)^{0.3} * (T/6)^{1.2} \quad (2)$$

where:

E = PM_{10} emission rate (kg/VKT/hr)
S = Silt content of the soil (%)
V = Vehicle speed (km/hr)
W = Vehicle weight (Mg, where 1 Mg = 1,000 kg)
T = Number of tires (wheels) per vehicle

The values of the parameters above were derived as follow:

S The silt content of the site is based on the grain size analysis data provided by Donohue & Associates. The average silt content was estimated to be 33%.

V The velocity of the dirt-bike riders was assumed to be 30 km/hr (about 20 mph).

W The weight of the dirt-bikes was assumed to be about 0.06 Mg (60 kg). Combined with the weight of the rider (70 kg), the total weight is 0.13 Mg.

T The number of tires (wheels) per dirt bike is two.

Based on these parameters, the value of E (expressed as kg/VKT/hr) was calculated:

$$E = 0.85 \times (33/10) \times (30/24)^{0.8} \times (0.13/7)^{0.3} \times (2/6)^{1.2}$$

$$= 0.27 \text{ kg/VKT/hr}$$

The emission rate for a single dirt-bike rider at this site is calculated by multiplying by VKT (the number of vehicles, assumed to be one, times the speed of each) and dividing by the area of the landfilled area (34,500 m^2 based on site maps) yields the emission rate in units of kg/hr/m^2:

$$E = \frac{0.27 \times 30}{34,500}$$

$$= 2.3E-04 \text{ kg/hr/m}^2$$

Dividing by 3,600 sec/hr:

$$E = \frac{2.3E-04}{3,600}$$

$$= 6.5E-00 \text{ kg/sec/m}^2$$

The emission rate for one dirt-bike rider while on site is 6.5E-08 kg/sec/m^2. This is the emission rate during the dirt-bike riding event and is not an annual average.

<u>On-Site Dirt-Bike Rider</u>

Assuming that two dirt-bike riders ride together during each event, the emission rate would be twice the emission rate for one rider, or 1.3E-07 kg/sec/m^2.

Current Off-site Downwind Resident

Assuming four dirt-bike riders on site and assuming emissions may occur 78 hours per year (see Section 3.0), an average annual emission rate is determined:

$$E = 6.5E\text{-}08 \text{ kg/sec/m}^2 \times 4$$

$$= 2.6E\text{-}07 \text{ kg/sec/m}^2$$

$$E_{(annual\ average)} = 2.6E\text{-}07 \text{ kg/sec/m}^2 \times \frac{78 \text{ hrs/yr}}{8{,}760 \text{ hr/yr}}$$

$$= 2.3E\text{-}09 \text{ kg/sec/m}^2$$

Therefore, the annual average emission rate from dirt-bike riding on site for the off-site downwind resident is 2.3E-09 kg/sec/m^2.

4.0 CALCULATION OF PM_{10} CONCENTRATIONS IN AIR - CURRENT LAND USE

The concentrations of PM_{10} in air resulting from wind erosion and dirt-bike riding at each area were calculated using the box model (Hanna et al. 1982). The basic equation is:

$$C = (E * X)/(H/2 * u) \qquad (3)$$

where:

- C = Concentration of PM_{10} in air (kg/m^3)
- E = PM_{10} emission rate ($kg/sec/m^2$)
- X = Distance from upwind to downwind edge of the box (m)
- H = Mixing height of the box (m)
- u = Windspeed (m/sec) across the box

Values of these parameters were derived as follows:

E The emission rates were calculated as described in Sections 2.0 and 3.0, above.

X The distance from the upwind to downwind edge of the box was derived by measurement of the sampling map (refer to Figure 2-1) and was determined to be 206 m. The wind was presumed to be blowing from the southwest.

H The mixing height of the box is a function of distance from the source and turbulence of the air which, in turn, is a function of the roughness of the terrain. The value of H at the upwind edge of the site is zero. At the downwind edge, the value of H was calculated from the following equation (Pasquil 1975):

$$X = 6.25\ Z_0[(H/Z_0)\ \ln\ (H/Z_0) - 1.58\ (H/Z_0) + 1.58] \quad (4)$$

where:

X = Upwind to downwind distance (m)
Z_0 = Roughness height (m)

Based on a current roughness height of 4 cm (0.04 m), the value of H was calculated as a function of X to be 8.7 m. The average height over the whole box is then H/2.

u The average wind speed was taken to be 2.25 m/sec, based on wind speed measured at the South Bend/St. Joe weather station.

Current Off-Site Downwind Resident

Employing these input parameters, the concentrations of PM_{10} were calculated for wind erosion and dirt bike riding:

$$C_{(wind)} = (E_{(wind)} \times X)/(H/2 \times u)$$
$$= (2.9E\text{-}10 \times 206)/(8.7/2 \times 2.25)$$
$$= 6.1E\text{-}09\ kg/m^3$$

$$C_{(bike)} = (E_{(bike)} \times X)/(H/2 \times u)$$
$$= (2.3E\text{-}09 \times 206)/(8.7/2 \times 2.25)$$
$$= 4.8E\text{-}08\ kg/m^3$$

Therefore, the PM_{10} concentration for the off-site downwind resident is the total of the PM_{10} concentrations from wind and vehicular erosion:

$$\text{Total } C = C_{(wind)} + C_{(bike)}$$
$$= 6.1E\text{-}09 + 4.8E\text{-}08$$
$$= 5.4E\text{-}08\ kg/m^3$$

Dirt-Bike Rider

During a dirt-bike riding event, the PM_{10} concentration on site may be calculated by the same equation, using the emission rate for two dirt-bike riders:

$$C_{(bike)} = (E_{(bike)} \times X)/(H/2 \times u)$$

$$= (1.3E-07 \times 206)/(8.7/2 \times 2.25)$$

$$= 2.8E-06\ kg/m^3$$

5.0 EMISSION RATE FROM AGRICULTURAL TILLING - FUTURE LAND USE

The emission of soil particles into air during tilling operations depends mainly on the silt content of soil. Since tilling and related operations are usually done only when the soil is reasonably dry, surface moisture content is generally not a key factor. Also, emissions do not depend heavily on the specific tillage implement, if operations are at a normal speed (usually 8 to 10 km/hr). Based on direct measurements, the emissions of soil per unit area during tilling of land is given by USEPA (1988):

$$E = (5.38)(k)(S)^{0.6} \qquad (5)$$

where:

E = Emission rate (kg/hectare).
k = Particle size multiplier (percentage of total emissions below a specific size limit).
S = Silt content of surface soil (%).

The value of k for particles less than 10 μm (i.e., PM_{10}) is 0.21 (USEPA 1988d). The silt content is 80% based on grain size analysis data for the two samples located in the former crop area. Based on these parameters, the PM_{10} emission rate is:

$$E = (5.38)(0.21)(80)^{0.6} \qquad (6)$$

$$= 15.7\ kg/hectare$$

Assuming the tractor is moving at 8 km/hr and is pulling an implement about 5 m wide, it will take about 15 minutes to till one hectare (1 hectare = 10,000 m^2 = 2.5 acres). Based on this, the emission rate per unit area may be expressed as:

$$E = 15.7\ kg/10{,}000\ m^2/15\ min \qquad (7)$$

$$= 1.0E-04\ kg/m^2/min \div 60\ sec/min$$

$$= 1.7E-06\ kg/m^2/sec$$

Therefore, the emission rate for an agricultural worker is 1.7E-06 $kg/m^2/sec$. This is the emission rate during tilling and related operations and is not an annual average.

Assuming emissions from agricultural activities occur one hour a day for 10 days a year, an average emission rate is thus determined:

$$E_{\left(\begin{array}{c}\text{annual}\\ \text{average}\end{array}\right)} = 1.7E\text{-}06\ kg/m^2/sec * \frac{10\ hr/yr}{8{,}760\ hr/yr}$$

$$= 1.9E\text{-}09\ kg/m^2/sec$$

Therefore, the annual average emission rate from agricultural tilling on site for the hypothetical future off-site downwind resident is 1.9E-09 $kg/m^2/sec$.

6.0 CALCULATION OF PM_{10} CONCENTRATIONS IN AIR - FUTURE LAND USE

The concentration of PM_{10} in air resulting from agricultural tilling was calculated using the box model (Hanna et al. 1982). The basic equation is:

$$C = (E \times X)/(H/2 \times u) \qquad (8)$$

where:

- C = Concentration of PM_{10} in air (kg/m^3)
- E = PM_{10} emission rate ($kg/m^2/sec$)
- X = Distance from upwind to downwind edge of the box (m)
- H = Mixing height of the box (m)
- u = Windspeed across the box (m/sec)

Values of these parameters were derived as follows:

- E = The emission rate is 1.7E-06 $kg/m^2/sec$, calculated as described above.
- X = The distance from the upwind to downwind edge of the box is assumed to be 206 m (refer to Section 4.0 of this appendix).
- H = The value of H is 8.7 m (calculated previously in Section 4.0).
- u = The average windspeed is 2.25 m/sec.

<u>Worker</u>

Employing these input parameters, the concentration of PM_{10} in air for an agricultural worker is calculated as follows:

$$C = (1.7E\text{-}06 * 206)/(8.7/2 * 2.25) \qquad (9)$$

$$= 3.6E\text{-}05\ kg/m^3$$

Utilizing the same equation, the concentrations of PM_{10} were calculated for wind erosion (assumed to be the same as the current emission rate) and agricultural tilling:

$$C_{(wind)} = (E_{(wind)} * X)/(H/2 * u)$$
$$= (2.9E-10 * 206)/(8.7/2 * 2.25)$$
$$= 6.1E-09 \ kg/m^3$$

$$C_{tilling)} = (E_{(tilling)} * X)/(H/2 * u)$$
$$= (1.9E-09 * 206)/(8.7/2 * 2.25)$$
$$= 4.0E-08 \ kg/m^3$$

Adding the PM_{10} concentrations from wind erosion and agricultural tilling results in a PM_{10} concentration for the hypothetical future off-site downwind resident.

$$\text{Total } C = C_{(wind)} + C_{(tilling)}$$
$$= 6.1E-09 + 4.0E-08$$
$$= 4.6E-08 \ kg/m^3$$

Table A1-1 summarizes the calculated PM_{10} concentrations (kg/m^3) for each population of concern at the Himco Dump site.

7.0 REFERENCES

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TABLE A2-1 SUMMARY OF PM_{10} CONCENTRATIONS

Land Use	Population	Event		PM_{10} Concentration (kg/m^3)
Current	Dirt-bike rider	Dirt-bike riding		2.8E-06
	Downwind resident	Dirt-bike riding		4.8E-08
		Wind erosion		6.1E-09
			Total	5.4E-08
Future	Agricultural worker	Agricultural tilling		3.6E-05
	Downwind resident	Agricultural tilling		4.0E-08
		Wind erosion		6.1E-09
			Total	4.6E-08